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and

The Foundry Trades' Equipment and Supplies Association

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The Tower of Babel

One of the most striking features of development in the foundry world is the extent to which published work is now coming from countries which formerly were not regarded as active in this field. Those who read the abstracts we print from time to time will have noticed this. These Papers cover both what may be conveniently termed foundry research and foundry practice. Their growth is undoubtedly due in part to the fact that foundry work, both ferrous and non-ferrous, is one of the earliest industries to be undertaken by a country developing its heavy industries, and in this respect the older and more fully developed countries set the pace. It is also inevitable that part of this new work should be based on and derived from the work of these older countries, but occasional original contributions are met which deserve very careful scrutiny. Thus we are accustomed to developments from Germany, France, Belgium and the U.S.A., but other countries are now entering the field, and among others we may note Spain, Russia, Poland, Italy, Czecho-Slovakia and Japan. It is difficult enough for the foundry executive to follow this progress in French and German, the languages in which, other than English, the bulk of foundry developments previously appeared, but with the addition of the other countries mentioned it makes more necessary than ever the use by the executive of the services of the technical Press, the technical institutions and the research associations in translating and making available this new material, and in assessing its value. Similar remarks apply to foreign patents, commercial literature, and so on.

All this raises in acute form the problems of technical translation, of the qualifications of a translator, of whether technical or linguistic knowledge is more important, of whether translations should be literal or whether they should aim at conveying the author's meaning regardless of a literal rendering, and so on. It raises questions of overlapping, and whether translations are made of the same articles by an unnecessarily large number of people, of the conversion of foreign units and testing methods into English or their retention as in the original, of the relative value of abstracts or complete translations. Finally, there are the questions as to whether different classes of readers require abstracted translations to suit their points of view; thus, a user of coke and a maker of coke will regard a given article from different aspects. To these points we shall return later.

Wear of Cast Iron

It is perhaps true to say that one of the properties of outstanding importance in cast iron, and a property which very often determines its commercial utility, is its resistance to wear. Cast iron is still regarded as the material *par excellence* for cylinders, pistons and rings in engines, compressors and pumps, and its resistance to other kinds of wear such as exist in machine tools and textile machinery, for example, is an outstanding consideration in determining its use. It is not surprising, therefore, that over the years there have been many attempts to study this property in cast iron with the object of determining the conditions of composition, physical characteristics and structure associated with the condition of optimum wear resistance. It is clear that wear resistance, like corrosion resistance, is not a specific property but is a property which can be associated only with the particular test conditions. The particular test conditions or circumstances thus become part of the definition of wear resistance. This is the difficulty in translating the results obtained in laboratory determinations to results of value in their application to industrial conditions. Laboratory determinations are usually carried out on apparatus designed to work under simplified conditions, and also to give results quickly, and such conditions are not necessarily similar to those obtained under actual service conditions. Even actual service conditions vary considerably, and it can be appreciated readily by any practical man that the conditions which exist in the cylinder of an internal-combustion engine may be quite different from those which exist in a steam engine or a pump.

A very interesting and concise general survey of this subject was presented by Pearce to the general discussion on lubrication and lubricants held by the Institution of Mechanical Engineers. The effect of composition, structure and thermal treatment were briefly but concisely reviewed. Stress is laid on the value of the fully pearlitic structure, and reference is made to the value of alloy additions. In referring to the effect of phosphorus it is stated that the hard phosphoric eutectic, in relief in a softer matrix, has the effect of the hard constituent of a bearing metal with respect to wear, and it is generally agreed that phosphorus increases wear resistance. Thus it can with advantage be used to the limit imposed by other considerations. The effect of

graphite is less certain. Little weight is now attached to the so-called lubricating effect of graphite present in cast iron, although the cavities may act as minute oil containers. Experimental and practical experience alike has shown that cast-iron structures containing flake graphite wear well, while the finely-divided eutectic or pseudo-eutectic graphite has been found generally to be bad for wear. It is yet uncertain whether this is a characteristic of all structures in which fine graphite appears.

The work of the Research Department of the Institution of Automobile Engineers is referred to, particularly the aspect of this work relating to the influence of corrosion conditions in so far as internal-combustion engine cylinders are concerned. This work has given fresh stimulus to the use of austenitic cast irons of the "Ni-Resist" and "Nicrosilal" types for cylinder liners. Reference is made also to the effect of heat-treatment in the production of structures containing the hard martensitic constituent and also the influence of nitrogen hardening.

Whilst there still remains a great deal of uncertainty surounding the nature of the conditions which exist in industrial cases of wear, and plenty of scope for further research and investigation, this review makes it clear that the work already done has been followed by a marked improvement in service life. It is also gratifying to observe that cast iron has proved capable of development in many aspects of its properties, resulting in the retention of its position as the principal material for the manufacture of cylinder components.

American Notes

(FROM OUR AMERICAN CORRESPONDENT.)

A pole reinforcement which may be used repeatedly, which is claimed to prevent snapping of poles at the ground line, and which may be quickly and cheaply installed, is being offered in America. The device consists of a malleable-iron stake support about six feet long, fitting snugly against the pole body, and bound to it by a steel band or clamped with steel clamps. About four feet of the support are driven below the ground surface, the overall length of the support being 5 ft. 6 in. As it is made of shock-resisting malleable iron, the support may be hammer driven without damaging it. The high ductility of the iron eliminates the danger of sudden failure or snapping, even though the constant weaving of the pole subjects the reinforcement to great strain. Pavement installations may be made easily, and, if required, two stakes may be used to provide double reinforcement. The stakes are manufactured in three sizes and weights, the weights having been calculated accurately according to pole height, span length, and wire load.

* * *

A greater use of precious metals in industrial operations is predicted by "Industrial and Engineering Chemistry," which recently completed a survey of gold, silver and platinum as materials of construction. While the report points out that precious metals in the past have been hurriedly dismissed as being too expensive, it is contended that the longer life and improvement in the product compensates for the high initial expense. Platinum and platinum-rhodium alloys are reported as satisfactory for resistors in very high-temperature furnaces, while other precious metals are being used successfully for electrodes, fuse wires, temperature indicators and laboratory ware. The report goes on to state:—"It is possible that, in turn, non-ferrous base metals will not be considered satisfactory in many applications, and in such places precious metals will be adopted in spite of much higher prices."

Correspondence

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

Sand Testing

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—In reply to Mr. Dearden's letter in THE FOUNDRY TRADE JOURNAL of December 9, I would like to make the following observations:—

(1) If standard densities are required, they should be found by mould hardness tests on moulds made of the sands under test (see the writer's earlier Papers). Hand moulding is controlled by the "feel" of the rammer, which is less a matter of using exactly the same energy than of producing the same hardness regardless of the amount of energy required. The moulder is very much interested in apparent density—but, of course, not always under that name. The variables mentioned have a very considerable effect on the A.F.A. test—much more than on the B.C.I.R.A. if the latter is used properly.

(2) Mr. Dearden should refer to the JOURNAL of May 20, 1937, page 407, Fig. 3, for another published example of permeability being increased by water content when measured by the A.F.A. method. The increase in water to 12 per cent. would offset any improvement in permeability by the extra steam evolved during casting—in which case it would not exactly be a "god-send." The usual place for the moisture is the clay bond, I should say, but the flowability could be altered, and this would make the sand ram differently under the A.F.A. rammer. In any case, the permeability is only said to be improved in the A.F.A. test-piece, not necessarily in the mould, which is a different story.

(3) and (4) I am interested to hear that Mr. Dearden has proof that his double compression test-pieces are soft in the middle, and in that case he is certainly entitled to his opinion, but those I have tested (and I have tested a great many without the aid of an assistant, and by a more accurate method) showed no variation throughout, and it is under these conditions that I have found the long test-piece to be correct in proportions for compression strength.

(5) I referred only to this statement as being based only on research on test-piece sizes and not derived from engineering principles or text-books, because much of the early discussion was based only on argument. Clay, being nearly of the same specific gravity as sand, cannot cause serious errors when the ramming of the test-piece is controlled by weight and, here again I must add, "properly used."

(6) Errors in weight must, of course, make more difference in the B.C.I.R.A. test-piece. My point is that there is no reason why the errors should be present at all.

The ramming conditions can be studied more rationally by making the A.F.A. test-piece, as I have suggested in my Paper in THE FOUNDRY TRADE JOURNAL of March 9, 1933, by double compression, and the necessary extra plunger has been listed in the catalogue of Ridsdale & Company following this suggestion, for at least three years.—Yours, etc.,

WM. Y. BUCHANAN.

John Lang & Sons,
Johnstone, near Glasgow.

Catalogue Received

Sodium Cubes. "Foseco News," the house organ of Foundry Services, Limited, 285, Long Acre, Nechells, Birmingham, 7, deals with the furnishing of metallic sodium cubes, cut to definite size to suit standard weights of molten aluminium-silicon alloy charges, and wrapped in aluminium foil to eliminate danger in handling and storage. This issue also deals with several types of fluxes for both light and heavy non-ferrous alloys.

Random Shots

With Christmas so near at hand and so many villages "icilated" because of the appallingly seasonable weather, it is hard to let the imagination run to a country where they are having a very hot time, but once again news comes from fellow workers in China. This time the enamelling department of the Shanghai gas works recently had to be closed down for a time because it was right in the line of fire; bullets and shrapnel came in through the windows; a three-inch shell entered through the lift shaft and another in the yard. The enamel bags, however, proved very useful receptacles for sand when such protection became necessary. One can almost hear the cool and collected English manager of that enamelling shop giving the order to the coolies to fill those blinking bags with sand and don't get frit! Here in England one has to be thankful that almost the only danger imminent at this season is that Father's cotton-wool beard might catch fire on Christmas Eve, though even that can be serious if it deprives the pattern store of the only man who can lay his fingers on the right pattern at the right moment.

* * *

Sir William Larke at a recent luncheon bids everyone be bright and cheerful: "Pessimism never paid any dividends and confidence is at least 50 per cent. psychological." So away with fears for Father's cotton wool beard and hearken unto a story.

* * *

The men had gone home, the works were locked up, and only the night watchman was left on duty, when in the fettling shop, at dead of night, the castings came to life. Said Mother Casting to her daughter on seeing a consignment of die castings coming her way, "Look the other way, dear, there's a Nudist colony coming along!"

* * *

Then there is the inevitable story of the Scotsman with a large family and a small income, who solved the Father Christmas problem in a truly Scottish way. Taking his son's toy gun on to the roof he let off a few noisy bangs and then dashed into the children's bedroom in great concern. "Did ye hear those bangs, my bairns?" says he. "Ah'm verra sorry to tell ye that Father Christmas has committed suicide."

* * *

"The China clay industry for October almost surpassed the most sanguinary expectation," says a contemporary journal. Why not be honest? In the foundry industry they call a spade a spade.

* * *

"One of the last strongholds of cast iron and cast steel is in the construction of heavy bedplates," says yet another contemporary journal. Amongst the real intelligentsia of the foundry industry it has always been understood that the last stronghold lies in sash weights and sausage machines.

* * *

FRENCH WITHOUT TEARS—IV.

"Ivre comme un Polonais."

And so the foundrymen will feel at home in Poland next year.

A—a = "Un grand appétite." And with this "Marksman" wishes all his foundry friends a very big and grand appetite for the Xmas turkey!

MR. E. GRAHAM CLARK has been appointed secretary of the Institution of Civil Engineers in succession to the late Dr. H. H. Jeffcott.

The Production of Some Intricately-Cored Iron Castings

By T. R. HARRIS

This Paper was the winning entry of a Prize Competition organised by the Lancashire Branch of the Institute of British Foundrymen. It was personally presented by the author to a meeting of the Branch sitting under the chairmanship of Mr. R. A. Jones (Branch-President). Mr. Harris is an Associate Member of the Institute, attached to the London Branch, and is in charge of the foundry of Holman Brothers, Limited, of Camborne, Cornwall.

In a Paper on modern ferrous foundry practice, there is a large number of themes that could be discussed. For instance, there are the vast improvements made in recent years in grey iron metallurgy, together with the introduction of the newer types of melting equipment, such as the balanced-blast cupola and the various furnaces using pulverised fuel in which superior results are obtained; or the unprecedented application of mechanisation to some foundries could be considered, together with the attendant factors of mass production and the consequent reorganisation of many foundry plants throughout the kingdom, with the result that to visitors they appear more like machine shops than foundries.

MR. T. R. HARRIS.

It is thought, however, that a description of the production of some typical intricately-cored castings would be of more interest to the majority of journeymen patternmakers, moulders and coremakers, rather than a scientific treatise on some abstract aspect of foundry work. Thus it is that the author has chosen the theme, "The Production of Some Intricately-Cored Iron Castings," as illustrating some aspects of modern foundry practice, for in many instances, had it not been for the technique developed in recent years, their production—at a commercial figure—would have been practically impossible.

The demands of modern engineering for intricate castings embracing what previously had been separate components may be ideal from the engineer's point of view, but is a considerable source of anxiety to the foundryman, especially when he is called upon to produce cylinders and other pressure vessels. Often a casting can be made which looks perfect, but which, on the application of the hydraulic pressure test, weeps at a number of places due to porosity—one of the foundryman's greatest troubles.

Post-War Changes

The following examples of intricately-cored castings are typical of many others that are produced regularly in a shop which, in pre-war days, was chiefly producing larger and heavier castings for pumping, winding and air-compressing engines. In the post-war period a re-organisation took place, and a speciality was made of smaller air-compressing and pneumatic plant which called for very intricate castings. The technique necessary for producing these castings varies considerably from that in vogue in the days of heavier work. Then, loam moulds were the order of the day, produced by the minimum of pattern work, and a "dull" iron was ideal for casting the heavy jobs.

To-day, all this is changed. Castings with walls of $\frac{3}{16}$ in. thickness demand the use of "hotter" iron, and the mould and cores have to be well made. The production of intricately-cored castings calls for the closest co-operation between patternshop and foundry, and only wood of exceptional quality should be used in the construction of the pattern and coreboxes. The introduction of oil-sand cores was one of the biggest benefits which has come the way of the founder in modern days, and the following examples owe much of their success to the use of this medium. Great care has to be exercised in the choice of workmen for these jobs, and in many cases it takes a considerable time properly to train a man to be capable of producing this class of work, particularly the first example to be considered. Expert supervision is necessary in the coreshop producing these cores, and care has to be exercised in their proper drying. Oil-sand technique differs from that required in naturally-bonded cores, both in making and drying. The older type of cores needed ramming, and on drying the combined water was evaporated, while artificially-bonded cores need not be rammed, and the drying process is essentially chemical. Oil-sand cores are dried by oxidation, and it is not a question of moisture removal. Best results are obtained with low-temperature stoves with good air circulation, a suitable temperature being about 205 deg. C.

L.-P. Cylinder Moulding

The first example chosen to illustrate the theme of the present thesis is a low-pressure cylinder for a two-stage air compressor. From the illustration, Fig. 1, it will be seen that it is a fairly complicated cylinder. The views are a number of sections through the various planes indicated, and are self-explanatory. In the first place, it will be observed that the design is not ideal from the founder's point of view, as there are thick and thin sections of metal in juxtaposition, and many lumps occur where the metal has been bossed-up to receive a stud. These all tend to produce "draws" through which the water will leak on test. Then, again, the water-jacket core is a source of trouble, for it is very thin in some places and also has only a very limited outlet for the gases generated on casting, and unless proper precautions are taken, it will "blow" and thus tend to cause porosity.

Castings such as this example can only be produced successfully after the most careful planning beforehand of both the moulding and coremaking technique, while the choice of a suitable metal mixture for the job is of the greatest importance. The normal procedure in work of this nature is for the patternmaker, on receipt of the blue-print, to lay the job out full size on a suitable drawing board, with space between the views to mark in the necessary machining allowance, core prints, etc. Before any patternmaking is done, a consultation between the patternmaker and foundry superintendent decides on the method of moulding which will be adopted.

Mould Construction

In the present instance it was decided to cast the job open end up, or in a similar position to the illustration, the joint of the mould being taken on top of the pattern. On a cursory examination of the drawing it might be thought by some that a better plan would be to split the pattern along the line CD, thus moulding in two boxes, the object being ease in assembling the cores. This, however, is unnecessary, and results in a fin of metal around the joint, which while not taking away from the usefulness of the casting detracts from its appearance, which is sometimes worth a little extra care, especially on high-class engine work. The pattern is "boxed" up, and the various facing pieces, J, J, etc., each carry a core print and are kept in position by dovetails. These dovetails extend the full length of the pattern and carry all the facings, which rest on them. Also the dovetails are made of aluminium, it having been found that no matter how perfectly fitting a wooden dovetail may have been made originally, or how well seasoned the timber from which the pattern has been constructed, invariably after a little while a wooden dovetail "sticks" and tears up a portion of the mould, a trouble not experienced with the use of aluminium.

Core prints are placed on each facing, and are made a little on the big side to allow of the easy insertion of the core on assembly, it having been found with dry-sand work that if both core print and corebox be made the correct size, the moulder has to resort to the use of a file to allow of the cores entering their respective prints. Also, the side prints are "guided," that is they each have a distinct difference imparted to them which is reproduced in the corebox, and so on assembly of the mould this can be proceeded with, without the necessity of the presence of the patternmaker in the foundry with blue-print. Especially is this wise in the present case, as the job is not symmetrical but the cores have a similar appearance which would need trying in position if no distinctive mark was given them.

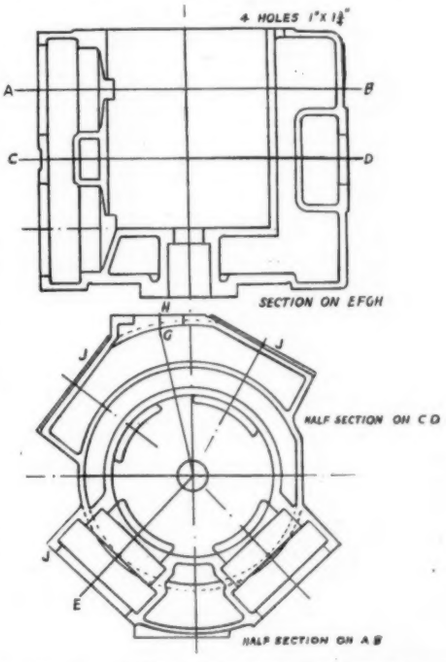


FIG. 1.—LOW-PRESSURE CYLINDER FOR TWO-STAGE AIR COMPRESSOR.

The centre core is supported on the print L and the chaplets, as shown in Fig. 2, while two 1½ in. dia. prints are placed in the bottom to locate and take off some of the gases from the jacket core at M, these holes being subsequently plugged. It will be noticed from Fig. 2 that no head is incorporated in this cylinder, although it is cast open end up. The reason is that no useful purpose is served by the employment of a head in this instance, as the results do not justify the extra expense incurred in moulding and subsequently removing it. Like most other jobs of an intricate nature, the coreboxes are

more difficult to produce than the pattern, and great care has to be exercised in their production to ensure the resulting cores fitting one another and being of the correct hand.

A *résumé* of the assembly of the cores in this mould is necessary to understand the reason for the various boxes making up this set.

Core Assembly

The first cores to be inserted are the four making the air-ways and valve pockets Z, Fig. 2. It will be observed that it would be impossible to insert water-jacket core Y after Z was in position or *vice versa* if the cores were made as in Fig. 1, because of the portion X, Fig. 2, forming the port. Consequently portion X has to be made as a separate core, and is secured in place after water-jacket core Y is in position. The four cores Z are therefore placed in position, next the jacket Y, and then the four small cores X, which are located by a print on Z, and wired back in position. These port cores and the top ones are kept back $\frac{1}{8}$ in. clear of the main core to avoid a "crush." To allow of the top jacket core being placed in position, core Z has to be made off to the line W, Fig. 2, and the portion V carrying the valve pocket and port is subsequently wired in position.

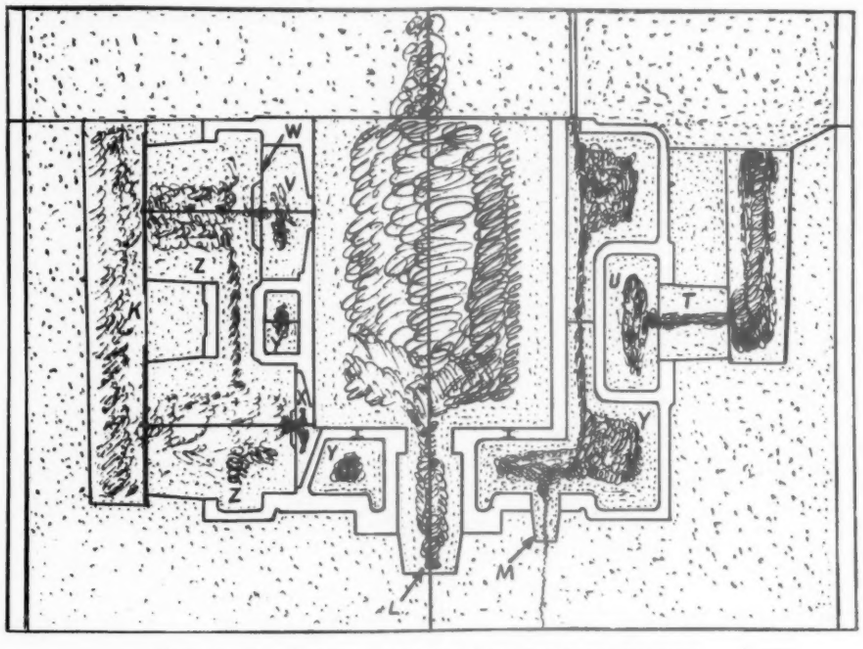


FIG. 2.—LOCATION OF CORES FOR LOW-PRESSURE CYLINDER.

To connect the air-way cores Z, a bridge piece is necessary at U, the whole being shown diagrammatically in Fig. 3, which shows various sections of the assembled cores and is self-explanatory. The air-inlet core T is made separate from the bridge-piece core, and is placed in its print before the bridge piece is inserted in impression in core Z. The boxes for cores Z are made as frames, with the interior filled in to shape, the top of the box being the print portion, these being loose in the frame, and also in halves for convenience in making the cores. The water jacket, as was suggested, is made as two cores jointed in the centre of the cylinder CD, Fig. 1, each piece of which is made in a frame box. To facilitate making this core, all pieces must be easily accessible and the box made accordingly with a large number of pieces, all of which suit in their respective positions. The cylinder bore is made in a full box while the bridge pieces U are made in suitable frame boxes, the top side being strickled off.

The boxes in which are made cores that abut against others have suitable places marked for the making of the necessary arrangements for the evacuation of the gases on casting. Such a case would be the bridge core-boxes, these being marked where the round core T suits, this being a means of venting core U. Places are also marked in the jacket boxes where cores for the sludge doors fit (these sludge doors are not shown in the illustrations to avoid complications).

Casting Desiderata

All the pattern work being finished, a start is made in the foundry and a number of important points given due consideration. Among these considerations are the questions: where is the best place to run the job; the number and disposition of risers; the venting arrangements for the easy exit of gases from the cores, etc. Dealing with these considerations in order, this particular cylinder is run from the bottom by two inlets connected with two downgates, these being connected at the top joint and fed by a common downgate. A great advantage of bottom pouring is that the fall of metal is broken, first at the top joint, then at the bottom, and can thus be gently led into the mould, and so save scabs, etc., which otherwise—if top-poured—would be caused by the erosion of the metal over certain parts of the mould and cores, with disastrous results.

Two risers are situated over the main barrel and between the water connection holes from the water-jacket core. The gases are taken off from the various cores in as many places as possible. The jacket core is the most difficult to make because of the restricted outlets for the gases generated on casting; it is made of a sea-sand mixture with a proprietary binder. This core is very delicate and is held together by wires (which are not shown in the illustration, but which are both circumferential and vertical), the objection to a cast-iron grid being that the size of the core is not sufficient to allow of a suitable-width grid and a layer of sand each side. Also, if a cast-iron grid were used, great difficulty would be experienced in extracting it from the casting. Some of the gas from the jacket core is taken off through the two bottom prints, but the bulk comes through the top "pods," and a little goes off through the sludge drain cores.

The method of taking off the gas through the top is to make the core $\frac{1}{8}$ in. shallow, and to mark on the pattern the centre of these various holes. In the top mould a number of vent holes are pierced through before the job is dried, corresponding to the position the hole in the jacket core will occupy on assembly. When the jacket core is in position, a ring of loam is built around the vent, and the top is placed on and seals it. In this way there is a free vent from the core to the atmosphere. Very fine ashes are used in this core to assist the venting, particularly of the larger masses of sand, which, if not artificially vented in this manner, would evolve an excessive amount of gas on casting. The vents would be inadequate to deal with this quantity of gas, and thus the gases would strike back into the metal and cause violent blowing, resulting in a waster casting.

The gases from the valve cores Z are taken off through the prints, as shown in Fig. 2. Space K is made during moulding by four patterns placed against each of the prints on the facing pieces J, J. The spaces left by these patterns are large enough to allow of the moulder placing his hand in and wiring the small port cores in position. The spaces afterwards are filled with fine ashes

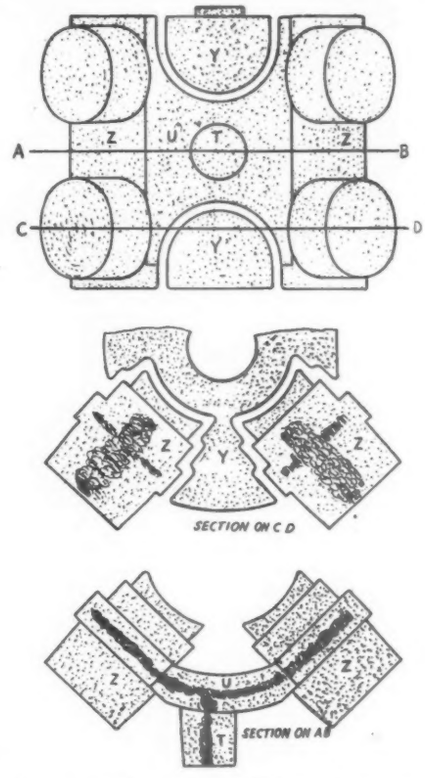


FIG. 3.—SECTIONS OF ASSEMBLED CORES FOR LOW-PRESSURE CYLINDER.

which lead the gases direct to the atmosphere. All the cores are made of a sea-sand and a proprietary binder. The best results are obtained by first drying the sand and then mixing a definite quantity to a proportion of binder in a "Rotoil" mill. The jacket and valve cores are made of a straight sea-sand mixture, but the centre core is made of a mixture containing a proportion of used moulding sand. All the cores have to be well made and "burnt out" to ensure safety on casting, because, the exits (especially from the jacket core) being rather restricted, an excess of gas is a great danger. Nevertheless, care has to be exercised that the core is not burnt over much and becomes "rotten."

The choice of a metal mixture for a casting such as this is very important, because, although the mould and cores are well made and carefully assembled, the use of an open iron would be conducive to "wasters" through weeping, etc. After much experimenting a steel-mix iron was evolved for this type of cylinder, and gave good results; porosity was reduced to a minimum and

the bore was even throughout, no hard spots being encountered. This particular cylinder was 13½ in. diameter, and the rough casting weighed 8½ cwts.

Making a Water-Cooled Casing

Another example that might be classed as an intricately-cored casting is illustrated in Fig. 4, and is a water-cooled casing. A number of features make this interesting, one of them being the thickness of metal compared to its surface area, which necessitates hot metal to run it successfully. On the other hand, the job would be safer if "duller" metal could be used to allow of the gases from the jacket core easily escaping. The job is cast face-down or, as Fig. 5, by three pencil runners, which ensures hot metal being used and also avoids excessive erosion. The pod of sand A is rammed with the bottom and is well stayed. It is also filled with ashes to assist in drying and venting and to avoid scabbing on the plate of metal. Joints are taken in the mould at YY and ZZ, the former to allow of inspecting the mould after the middle portion of the job is in place and the water-jacket core secured.

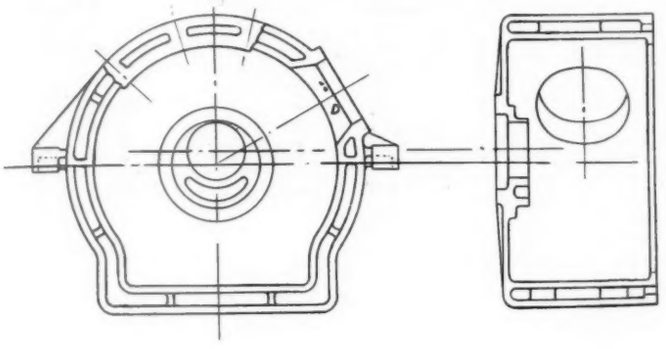


FIG. 4.—WATER-COOLED CASING.

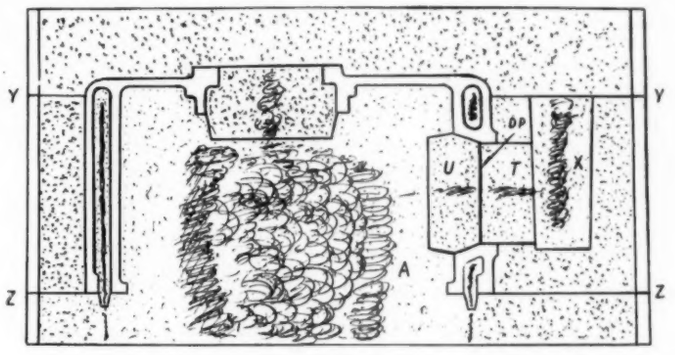


FIG. 5.—MOULDING AND CORING OF WATER-COOLED CASING.

Core Assembly

The water-jacket core is assembled in a number of prints around the bottom. These prints should be on the large side to allow of the core being easily inserted, and can be stopped around subsequently to keep the metal from entering the vents. This core is secured by wiring in position through the bottom, and is made in two pieces, being divided by the baffle plate in Fig. 4. Being only 1 in. wide and 11 in. deep, it would be a difficult matter to make these cores on end and handle them for drying, so they were made on the flat on aluminium coreboxes with the top scraped over, the aluminium boxes being utilised as driers. These cores are difficult to make, because of their narrowness, and great care had to be exercised in their production. Wires were the medium used to hold the core together, and a sea-sand mixture was used. Venting was accomplished by means of bars rammed up in the core and then withdrawn, leaving a number of exits to the atmosphere by way of the prints. Care had to be exercised to counteract the tendency of the core to spring on drying, and thus cause thin places on the casting.

A complication in assembling was occasioned by the inspection-hole core D. As can be seen from the illustration, it is impossible first to place core D in position and then assemble the jacket or *vice versa*. The method adopted to surmount the difficulty was to make the core D in two pieces, divided at line DP, Fig. 4, with a coreprint in "pod" A and the other in the middle mould T, Fig. 5. When the middle was being rammed up a space was made at the back of the print T, as in the previous example, and on assembly part T of the core was placed in its print. The core being somewhat shorter than the print, it was pushed back clear of the edge of the mould. The water jacket being in position the part U of the core is placed in position through the jacket. It will be observed that the joint of this core is within the jacket.

The middle—with the core well back—is now assembled, and the moulder then places his hand in the space X provided (already referred to), and pushes the core tight against its other portion and secured in position with core gum. The space is then filled with ashes and the vents made good. The feet on this casting were moulded with the middle portion, the space underneath being cored out and the cores built in before drying. Of course, the feet and all facing pieces, etc., were carried on dovetails. This casting was subject to a hydraulic test, and was a rather difficult job to handle.

Air-Cooled Air Compressor

The next example is an air-cooled air-compressor cylinder with a fairly complicated exterior, the valve pockets, ports and cooling fins complicating moulding operations. From a foundry point of view this casting is not as formidable as the previous examples, but is included as an example of intricately-cored castings because it illustrates the use of cores as an aid to moulding. Fig. 6 shows some sections of this casting, which consists of two cylinders of different diameter bore together with the crankcase portion and valve receptacles, etc., on either side, the cylinder and the ports being suitably ribbed. Because of the design it is impossible to split a pattern for this in any plane so as to allow of direct moulding from two halves, and thus the alternatives presented are either to mould from a pattern split along the centre line of the cylinder with the underlay portion cored out, or to make the whole of the exterior in cores.

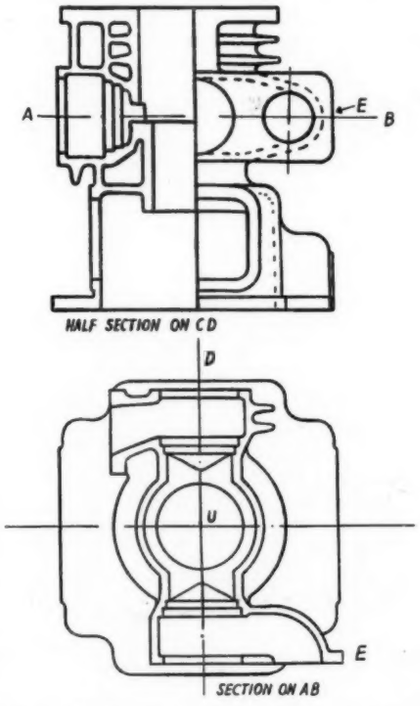


FIG. 6.—CYLINDER FOR AIR-COOLED AIR COMPRESSOR.

From a summing up of the possibilities it is found that a better and cheaper job can be obtained by making the exterior in cores. In this connection it may be well to notice one great advantage in making complicated work in cores as against moulding the job direct from a pattern, and that is in the method of withdrawing the pattern. A pattern can be withdrawn from the mould in only one direction, and any loose pieces must be small enough to enter the cavity formed by the main portion of the pattern and withdrawn later. The limits thus imposed by the method of direct moulding from a pattern are entirely eliminated in coremaking. A corebox can be stripped from either of its six sides, or any position intermediately; in fact loose pieces can be drawn out anywhere. Not only does this make for ease in withdrawing the pattern work but also in dressing the subsequent core.

Made as a Core Assembly

A mould with ribs and loose pieces that have been withdrawn after the main pattern is usually difficult to blacken, a disadvantage not found in cores. Thus the example shown was made in cores. The pattern consisted simply of a large rectangular prism with a coreprint for the cylinder bore core. Into the cavity formed by the pattern—which was in essence a print—the various cores were assembled. The moulding box in which the large print was rammed up is jointed so as to correspond to the joint necessary to insert the valve cores. The outside is made in four pieces, two from the face of the mould to the centre of the valve ways and the other two from this joint to the top, embracing the crankcase portion. The cores are made from a proprietary oil-sand mixture and care has to be exercised in drying to avoid the thin section of sand being "burnt." Assembly begins by placing the two bottom cores in position and then the valveway cores. The remainder of the mould is then placed on, and the other outside cores are assembled. The cylinder-bore core is next inserted, and the two hand-hole cores placed in position; the crankcase core then completes the coring of this mould. The job is run on one flange, as at E, and also on top, this arrangement ensuring that no gas is trapped on top; flow-off risers are situated on the opposite side to the runner on the top flange.

(*Concluded on page 494.*)

Moulding Boxes Built and Repaired by Welding

By H. HOWES-JONES

So successful was a welded repair to a moulding box that when volume of business made a large number of new flasks necessary the arc welding department received the usual inquiry: "What can you do and how fast can you do it?" Thus a new type of flask came into existence as a completely arc-welded job using only stock sheet and bar materials. The embossed groove running round both halves was particularly desired by the foundry as a means of locking the sand into the flask. This represented somewhat of a problem, since no dies existed for this, nor was there any prospect of additional work to justify tool construction.

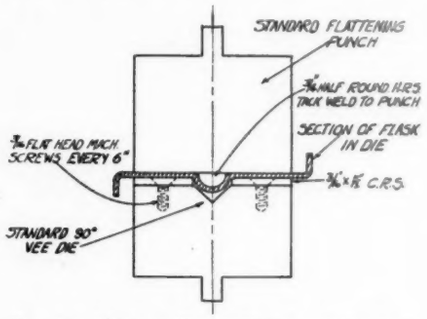

STANDARD FLATTENING PUNCH
¾" HALF ROUND H.R.S. TACK WELD TO PUNCH
SECTION OF FLASK IN DIE
¾" FLAT HEAD MACH. SCREWS EVERY 6"
¾"x¼" C.R.S.
STANDARD 90° VEE DIE

FIG. 1.—MADE-UP DIE TO FORM THE GROOVES IN EACH HALF OF THE FLASK.

The only solution lay in temporary changes to existing dies used in normal fabrication work, and Figs. 1 and 2 show how arc welding built the tools as well as the job. By taking a standard flattening die used in straightening and flanging work and welding to it a bar of ¾-in. half-round steel along its centre line, an embossing punch was produced, while to attach a pair of 7/16-in. by 1½-in. cold-rolled steel strips on either side of a standard vee bending die made up the other half of the tool, screws being used to permit the same or other strips being put on for other jobs. The made-up die functioned as shown in Fig. 1, with the edge flanges being first bent on a standard vee-type bending tool.

The forming of the flask sections into 18-in. by 13-in. rectangles, with 2-in. outside radii at each corner, was accomplished on another quickly fabricated tool, as shown in Fig. 2. The punch portion consists of a 4⅞-in. length of 3¾-in. dia. steel bar to which was welded a piece of ½-in. by ⅜-in. cold-rolled steel bar on edge as shown at the top.

This formed the holding tongue; then a piece of ⅜-in. half-round stock was formed to fit the round bar, and arc welded to it with the centre ⅛ in. off the transverse centre-line. This served to prevent distortion of the emboss during the corner-forming operation. Similarly, edge flange distortion was prevented by 2-in. by ½-in. C.R.S. pads welded to one end of the punch bar and the opposite end of the die which served to hold the flanges at right angles to the wall and prevent wrinkling of the corners.

Provision had to be made for the emboss to go below the normal surface of the die and not cut a slot that would spoil it for standard work. This was done by taking a 4⅞-in. length of a standard 2½-in. radius die, bending to it a pair of ½-in. thick bars, one 2 in. wide and the other 1⅞ in., and tack welding them to the die so that a 1-in. wide by ½-in. deep groove lay between them into which the emboss portion of the flask could go, as shown in the sectional view of the die in Fig. 2.

With the exception of those on the end pads, all welds were slightly stressed due to the greater portion of the load being carried through solid material, hence very small welds could be used, permitting the easy dismantling on completion of the work. One-quarter inch fillet welds were used to hold the end pads, as shown, and proved ample for a 300-flask run.

On completion of the forming work, the ends were butt welded together, using ⅛-in. heavily coated electrodes. The combined handle and locating pin bar consists of one 3½-in. length of 1-in. by ½-in. bar stock arc welded to the same length of 2½-in. by ¼-in. steel strap by a fillet weld along one side. The welding of the lug on to each end of the flask was done by running a 3/16-in. fillet weld around it, using a 5/32-in. dia. general purpose type of covered electrode. Such a weld has many times the strength required, but by making it continuous around the lug, a bond is obtained that no amount of rough handling can break or affect.

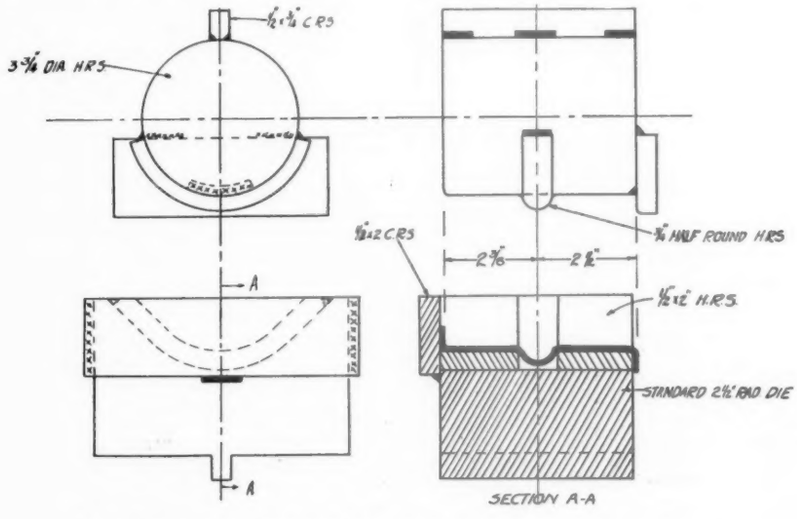


FIG. 2.—TOOL TO FORM THE RECTANGULAR SHAPE WITH 2-IN. OUTSIDE RADII AT EACH CORNER.

Drilling for the locating pins was done with a fabricated jig, as shown in Fig. 3, and made up of 2 in. by ⅜-in. side bars, 2½-in. by ⅜-in. end straps welded into a frame with butt welds at the corners. A 4-in. hole was drilled in a piece of 6-in. by 6-in. by ¾-in. steel plate which was then sawn through from the centre of each side to form the four corner locating plates. These were welded to the frame, as shown, while 5 in. of 2-in. by ⅜-in. bar was used for each of the drilling pads welded to the end straps, leaving the locating and drilling of the holes to carry the standard hardened bushings, all that was required to complete the fixture.

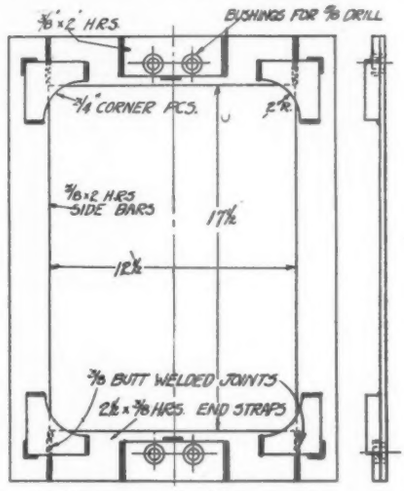


FIG. 3.—FABRICATED JIG USED TO DRILL FOR THE LOCATING PINS.

On completion of the order, these bushings were returned to the tool room stock, so that their use involved no additional cost but materially improved the accuracy of the pin holes. The insertion of the pin at each end, and the arc welding of it to the lug, completed the job with total costs of but a fraction of the best that could be obtained by other methods, while the time factor was taken care of by commencing deliveries four days after receipt of the acceptance of the sample.—"Canadian Machinery."

Organisation of the Iron and Steel Industry

Sir William Larke, Director of the British Iron and Steel Federation, spoke on the organisation of the iron and steel industry at a luncheon of the Royal Empire Society last week.

The iron and steel industry, Sir William Larke said, had always been more organised than most others, and when protection was granted in 1932, the Government had insisted that its economic organisation should be on a national basis. The federation included 15 separate industries, and the severity of foreign competition between 1921 and 1931, based on wage rates only half those of Great Britain, had left them with the choice between co-operation and bankruptcy. Prices had not been increased by protection, but only when, after three years, dearer raw materials and services were proved to have entered into production costs. Only when, in 1935, home protection had reached 50 per cent. *ad valorem* was an international convention negotiated, which had made it possible in the participating countries—in Britain for the first time for 10 years—to relate prices to costs. It had given a stimulus to industrial revival, and he would like to see other industries doing the same, for such agreements brought immediate economic advantage to the countries concerned. Every iron and steel industry in the Empire was a member of the British Federation, and the South African industry had entered into an agreement for the progressive development of that market.

Refining Steel in the High-Frequency Furnace*

By VICTOR STOBIE, M.I.E.E. (Past-President, Institute of British Foundrymen)

High-frequency furnaces for melting steel and other metals have attracted much attention during recent years, but their employment has not extended to the full field in which they can be useful. One main obstacle has held them back. Their utility has been confined to plain melting, which has necessitated employing only the purest raw materials. This has not placed them favourably compared with refining furnaces. The obstacle has now been removed and, as has long been desired, the melt can be refined.

Some interesting experimental work on refining in the high-frequency furnace has been carried out by research associations and industrial concerns abroad in the last few years, mainly in Germany and Sweden. Those efforts have shown the impossibility of refining in the ordinary furnace with commercial success, as their crucibles cannot withstand the attack of the refining slags. Most types of steelworks refractory were tried during the experiments. Some of the workers endeavoured to obtain better results by changing the periodicity of the electricity supplied to the furnaces; but, unfortunately, nothing useful was achieved.

On reviewing the characteristics of the ordinary high-frequency furnace, the author noted the following:—

(1) The surface of the molten metal and, therefore, the slag-line, is below the level of the inductor coil, that is to say, it is within the heating zone of the furnace. Almost the whole of the heating of the charge of steel takes place, when once the metal is molten, in the thin circumferential layer of steel which lies against the crucible wall. That steel which touches the crucible and, consequently, the crucible surface itself, are hotter than the average temperature of the charge. The super-heated surface of the crucible at the slag-line in the ordinary high-frequency furnace is, therefore, initially handicapped in resistance to the slags.

(2) The thickness of the crucible wall at the slag-line in the ordinary high-frequency furnace cannot be made greater than some two or three inches, for known electrical reasons. Also, those walls are vertical and cannot be repaired between heats, as suitable repair material will not stick to them.

(3) The very strong surface turbulence of the metal in the ordinary furnace, if refining is attempted in it, causes the powerfully active slags to erode the crucible, which extends the chemical destruction of its wall. Contrary to frequent supposition, strong electrical turbulence of the metal is not required, nor even desirable, for refining steel. A gentle electrical mixing of the steel is of advantage to ensure a constantly renewed portion of the bath being presented to the slag, but anything more is seriously against control of refining; against the life of the lining; and, incidentally, a fractional waste of energy. Nevertheless, some Continental workers have sought for successful refining by increasing the violence of the turbulence. The author, on the other hand, finds a turbulence of the steel greater than that produced by the refining reactions, plus a gentle circulation electrically added, to be an impediment to the best work and destructive of the furnace.

* Paper read before the Scottish Branch of the Institute of British Foundrymen in Glasgow on December 11, Mr. E. J. Ross presiding.

The Turbulence Phenomenon

A word or two concerning the turbulence at the surface of the molten metal in both the ordinary and the refining high-frequency furnace (see Figs. 1 and 2) may be of interest to those who have not studied its origin. When current is on the furnace, the molten bath rises higher in the centre of the surface than at the sides, and the higher steel pours continuously down the slope. The height of such a "fountain" is greater, in a given furnace, the greater the current supplied to the furnace coil.

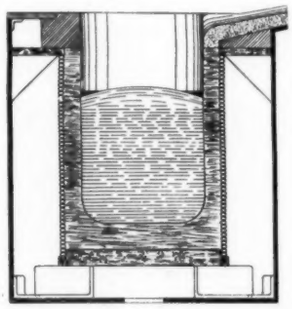


FIG. 1.—ORDINARY HIGH-FREQUENCY FURNACE.

It is due to repulsion between the current in the furnace coil and that induced in the molten steel. It is not, in any measure, dependent on the frequency of the current; and a low-frequency current produces, in a given furnace, a smaller "fountain" than does a higher frequency current because the lower frequency current has the higher power-factor and, therefore, necessitates less current in the furnace coil for a given energy input, notwithstanding the square-root heat effect of frequency. If frequency of current, *qua* frequency, regulated the height of the "fountain," as might be inferred

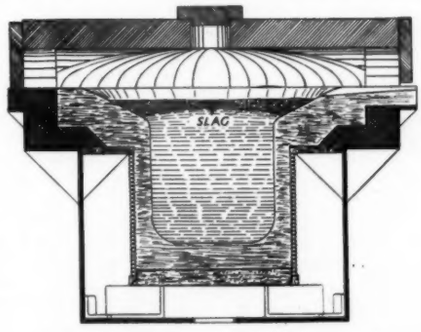


FIG. 2.—REFINING HIGH-FREQUENCY FURNACE.

from one text-book, an accelerated "fountain" would accompany increased frequency of current in accordance with all motion governed by electrical frequency, and the greater momentum thus acquired by the steel would heighten the "fountain."

The solution for a successful refining high-frequency furnace appeared to be the following:—

(1) The slag-line must be located higher than the superheated crucible wall, instead of being within the heating zone of the furnace.

(2) The refractory lining at the raised slag-line must be much thicker than the few inches available in the crucible wall of the furnace.

(3) The slag-line must be fully repairable after each heat.

(4) The surface turbulence of the metal from electrical cause must be reduced.

A furnace was evolved which met those requirements. The ease with which refining is conducted in it has justified the work. As is seen in the illustration, Fig. 2, the furnace resembles the ordinary high-frequency furnace in and around the lower half. The inductor coil, which surrounds the crucible and transmits heat energy to the steel, does not extend upwards past the surface of the molten bath as in non-refining furnaces, but is short and finishes lower down. The inductor coil does not, therefore, enclose the whole of the charge. The higher part of the lining, where it continues above the coil, is thickened to 12 in. or more, and is sloping on its exposed surface, like the banks of an arc or an open-hearth furnace. The coil carries the full electrical energy required. The shortened length of coil has proved more efficient than the long coil of non-refining furnaces. This may seem contrary to text-book theories, but the cause lies mainly in a higher power-factor of the coil, due to its conditions of use. The furnace is covered by a well-fitting sillimanite roof. It has the usual advantage of ordinary high-frequency furnaces of being a rapid melter from which a large output can be taken in frequent small quantities.

The steel charge above coil level is held unfailingly at the full heat of the remainder of the bath by two happenings. One is the continual rising of the hottest steel by normal convection; the other is the ever-upward flow from below of the "fountain" of steel. The weight of steel above coil level, in other words, that above the region where the "fountain" originates, supplies the final requirement for good refining by spreading the undesired portion of the "fountain" before it can over-agitate the surface.

Metallurgical Considerations

A metallurgical question which will be formulated here will be: What heat is available for activating the refining slags? The answer meets every requirement. The fluidity of the slag is dependent on, simultaneously, composition and temperature. Refining activity is dependent on the inducement the slag and the molten steel offer each other for the required chemical changes. The heat reached by the liquid slag is almost that of the steel, and the adjustment of the slag to give vigorous refining activity has presented no difficulty at any time. The inside of the roof, after refining has commenced, rises almost to the temperature of the liquid slag; and the sillimanite roof is an excellent conservator of that heat.

Carbon in steel can be reduced in this furnace until a finished high-quality material with the low content of 0.02 per cent. carbon is obtained, which is three or four times lower than is possible with arc furnaces. Silicon, manganese, sulphur and phosphorus are reduced at the same time. Sulphur is well lowered but, so far, not to the extremely low limit possible, at a cost, in the arc furnace. That extreme limit, however, has little purpose, and is not to-day considered of special merit by metallurgists.

The refining process is a plain one. The data below indicate the removal of carbon, silicon, manganese, sulphur and phosphorus from carbon steel scrap when the furnace is basic lined. The scrap used varied between:—C, 0.45 to 0.65; Si, 0.20 to 0.35; Mn, 0.65 to 0.90; S, 0.04 to 0.06, and P, 0.04 to 0.06 per cent.

The composition of the refined steels after casting is shown in Table I.

Ferro-silicon was added in differing quantities prior to tapping, but no ferro-manganese, as the steels were not intended for direct use.

Well-tried experience of presumed 0.02 per cent. carbon steels made it appear reasonable to have check-analyses of 0.02 per cent. carbons from this furnace. These were made by a reliable disinterested and independent steelworks, and they returned 0.02 per cent. on each of four estimations. The slag materials used at the commencement of refining consist of lime and sand in proportions to flux shortly after iron ore has been added to the bath. Thereafter, only lime is fed in; the necessary additions of this being recurrently demanded by the unmistakable changes in the slag whilst refining proceeds.

TABLE I.—*Composition of the Refined Steels.*

Heat No.	C. Per cent.	Si. Per cent.	Mn. Per cent.	S. Per cent.	P. Per cent
135	0.02	—	—	0.030	0.008
136	0.02	0.29	tr.	0.031	0.008
137	0.03	0.20	tr.	0.030	tr.
141	0.03	0.08	tr.	0.033	0.021
143	0.03	0.21	0.07	0.033	0.020
148	0.03	—	—	0.023	0.012
149	0.04	0.33	0.04	0.020	0.007
151	0.02	0.22	0.03	0.022	0.011

The fluidity of the slag is an impressive sight to those accustomed to the ordinary high-frequency furnace. Its greed for lime as the refining proceeds is, metallurgically, most gratifying. Ore is added as and when familiar bath signs indicate the requirements. It splits into small bits on contact with the molten steel, and operates at the surface under the slag.

Visual Reactions

The refining is accompanied by changing types of gas puffs issuing from the bath; changing nature of the slag; changes in the movements in the slag; changes in the movement of the bath; and changing vigour in these very changes. All these indications are constantly in view of the operators through the shallow and nearly clear furnace atmosphere, and they constitute an exact guide, step by step, to the progress of refining. After short practice, it can, for example, be told from the movement of the slag and bath whether the carbon is reduced to 0.03 per cent. or whether it is down to 0.02 per cent. The guidance to blowing visible to the expert blower in the classical case of the Bessemer flame is rough compared with the niceties which guide in high-frequency refining.

Lime additions during refining are best directed largely towards the edge of the slag, where it meets the sloping banks of the lining. This has advantage in reducing the slag activity against the slag-line, by somewhat lessening the temperature there, whilst its briskness over the main surface of the steel has full play. Following normal steelmaking practice, the drive of refining is relaxed towards its finish, so as to end the process with low excess oxygen.

When refining is completed, the slag is poured off and some deoxidant is added to the bath. Fresh lime, sand and, perhaps, a little fluorspar make a pliant finishing slag. Concluding additions (finishings) to the steel are then made. The finishing of the steel is effected under favourable conditions through the critical insight obtained of the melt.

The time required for refining varies according to the result desired. Broadly speaking, it is between twenty and forty minutes. Full power is maintained on the furnace during the height of refining, and varied at other times to suit requirements.

Slag Desiderata

The composition of the slag changes much during refining, so a "typical" slag would be a misnomer. Examples contain at different periods:—SiO_2, 45 to 15 per cent.; Fe (calculated as FeO), 35 to 20 per cent.; CaO, 35 to 15 per cent. Prior slag experience must not lose its proportion as a guide when considering these values. In most other refining processes the slags are hotter than the metal, and some metallurgists may have become so accustomed to that condition that they incline to assume, without inquiry, that there is fundamental merit in it. A thought given to Bessemer reactions will annihilate the suggestion. An examination of the events occurring in the refining high-frequency furnace has shown, beyond question, that it is the oxygen received by the bath from the ore which does the main refining; and the function of the slag is to hold the oxidation products securely as they rise into it from the steel. For the slag to retain these products it is necessary that its composition, at its temperature, shall have affinity for them greater than has the steel. Nothing more is required. The slag certainly contributes in degree to the refining by its excess content of iron oxide, and such abstraction of the oxide from the slag is convenient so long as the excess is maintained.

The efficacy of the refining provisions is such that, when refining was begun on the first charge to be treated, the reactions were most alarmingly energetic, and it became necessary to show a little less enthusiasm in urging for immediate high speed. The furnace could work quicker than the operators, so the refining was tempered whilst the furnacemen gathered experience. Progressively with the men becoming more skilful, so the furnace was given its reins.

Easy Control Established

It has been suggested in the past that there would be objection to using a high-frequency furnace for refining because of the undesirability of holding the molten bath in a quick-working furnace long enough for making necessary analyses to indicate the progress of refining. This position does not arise. No bath analyses are required during refining, beyond the one taken when the charge is first melted. This may sound, at first, rather venturesome; but experience has established it beyond question. The reason for this economy is that the course of refining becomes automatic within very narrow limits. The furnaceman has a constant view of the charge, and the unobscured furnace atmosphere makes it easy for him to follow every event in the furnace, like examining the symptoms of chemical indicators on the laboratory bench. The bath and slag reactions are the straightforward fulfilment of deliberately intended activities, unvitiated by carbon or producer gases, and unconfused to the eye by radiations from arcs or imported flames. The slag, the bath and the reactions are seen in undisguised reality, giving perception to the furnaceman which has no equivalent in earlier work. The ore and lime are added until the indications are that the carbon is low. The fluidity and appearance of the slag are unmistakable during this time, and, after a short experience, the maintaining of sufficient lime in the slag to retain the oxidation products is a matter of routine.

The Carbon-Monoxide Atmosphere

An interesting observation is that, if the carbon monoxide atmosphere generated during refining remains under the roof, the refining is remarkably slower than when air is admitted to burn the gas. To facilitate this, the hole through which ore is fed through the roof is kept partly open. A carbon-monoxide-saturated atmosphere cannot accept additional CO, either from the slag or from the bath. In a saturated atmosphere, the slag quickly reaches CO saturation, and the steel a balanced concentration. Diffusion of the gas from the bath into the slag or into the furnace atmosphere, or of that already in the slag into the furnace atmosphere, will not proceed while the concentrations are in equilibrium, and only, at other times, at a speed inversely proportional to the concentrations. There must exist a gradient of CO across the slag and atmosphere along which newly generated gas may flow, otherwise the steel will unload the gas only to the extent that the rising pressure within it can force a liberation by bodily pushing the previous atmosphere out of

FIG.3.—STOBIE REFINING HIGH-FREQUENCY FURNACE INSTALLATION.

FIG. 4.—REFINING HIGH-FREQUENCY FURNACE, SHOWING END OF TAPPING.

the furnace. Under those conditions, refining is slow. When the CO rising from the melt is burnt by incoming air, refining proceeds at high speed.

One deals with but part of the whole when considering metal/slag balances, only, in relation to refining. The picture requires concurrent appreciation of metal/slag/atmosphere equilibria. These three parties to the negotiations have each equal importance when the subject of inquiry is the itinerancy of an oxidation product which is, or is susceptible of becoming, a gas; and, in all cases, the analysing of a slag to examine its relation to refining is incomplete if it is devoid of indication of gases held in solution which can produce oxidation products or which can react on them as they rise from the metal.

The fully oxidising atmosphere deliberately maintained above the slag in the present furnace during refining is the probable cause of the greater desulphurisation than is experienced in other oxidising processes. In an open-hearth furnace such an intensely oxidising atmosphere might entail ruin of the refractories by an accompanying severely destructive heating flame. In an arc furnace, when, as is usual, air enters during the oxidising refining, the atmosphere over much of the slag may be more oxidising than in an open-hearth furnace, but the ever-present carbon burnt or volatilised from the electrodes, and the necessary tight roof, still impose a vitiated atmosphere.

Though insufficient work has been done to establish it decisively, the author suggests that much of the sulphur removal by the present process is by direct formation of sulphur dioxide gas in the bath. He is aware it is sometimes stated that such a reaction cannot take place because the heat of formation of sulphur dioxide is lower than that of the involved ferrous oxide and metallic sulphide. No such selectivity determines refining activities. The reaction can occur providing its absorption of heat does not reduce the temperature of the reactants below a sufficient residual value. If heats of formation governed, carbon could not be removed from molten steel.

Nature of Slag

A final falling slag is producible at will for finishing, if desired, but was not used on the above heats. Many slags of different silica-lime relationship will "fall," providing they contain little or no iron or manganese oxide, and a number can be produced at lower than steel-making temperatures. It is known to arc-furnace operators that a falling slag is not, as was once thought, the indication of a well-finished steel. Appalling steel can lie under the finest falling slag! It can, and fortunately usually does, accompany well-conditioned arc-furnace steel, but its presence is evidence only of high lime-content and of a sufficient lowness of the mentioned metal oxides.

Two examples of falling slag from the refining high-frequency furnace contained:—

(i) SiO_2, 28.5 per cent.; FeO, 0.86 per cent.; Ca (as CaO), 66.8 per cent.; MgO, 2.5 per cent.; C nil.

(ii) SiO_2, 30.0 per cent.; FeO, 2.04 per cent.; Ca (as CaO), 63.5 per cent.; MgO, —; C nil.

No carbon or carbon-containing material was used in their production. The falling slag of an arc furnace usually contains calcium carbide and, sometimes, other carbides; but no trial has been made with a carbide added to the present slags.

Economic Factors

Adding alloys to the refined product to make special steels is not technically dealt with here, as it does not involve anything new in steel-making to those accustomed to such steels. The economic factors are, however, interesting. With high-quality stock of 0.02 per cent. or 0.03 per cent. carbon, a number of previously more or less locked doors are opened wide. An example is the production of silicon steels with ultra-low carbon for electrical purposes. Energy losses by hysteresis rise and fall in such steel with the carbon content. The value of a number of nickel steels for electrical purposes also depends on their lowness in carbon. An illuminating opening is in low-carbon stainless steels. The 18/8 type, made with 0.1 per cent. carbon ferro-chrome and 0.03 per cent. carbon refined stock, will give a final 0.05 per cent. carbon. Using 0.07 per cent. carbon ferro-chrome and 0.02 per cent. refined stock, the final carbon will be 0.035 per cent. Metallic chromium with the 0.02 per cent. refined stock will give 0.012 per cent. carbon. If the finished steel required is the usual 0.1 per cent. carbon, ferro-chrome having up to 0.25 per cent. can safely be used. The improvement in a number of ferrous and non-ferrous alloys following the reduction of their carbon content has been an outstanding feature in the last few years.

Interest in the refining high-frequency furnace does not centre solely around the virtual elimination, when desired, of carbon. It is the new degree of exactitude in modelling steel and other metals to requirements, with increased ease and commercial advantage, which attracts the attention.

Book Review

Tungsten. A Treatise on its Metallurgy, Properties and Applications. By Colin J. Smithells, M.C., D.Sc. Published by Chapman & Hall, Limited, 11, Henrietta Street, London, W.C.2. Price 25s. net.

This is the second edition of Dr. Smithells' treatise on tungsten, and reflects the author's unique facilities for investigating this metal and compiling data from many sources. Some idea of the amount of new matter included in the present edition may be gathered from the increased length—272 pages, as against 167 in the first edition.

In view of certain very specialised and highly important fields of application of tungsten, the author has enlisted the aid of three other experts, who have written entirely new chapters, dealing with the "Thermionic Properties of Tungsten" (Dr. A. L. Reimann, F.Inst.P.), "Tungsten-Iron Alloys and Tungsten Steels" (Mr. J. H. G. Monypenny, F.Inst.P.), and the "Hard Alloys of Tungsten Carbide" (Mr. T. R. Bird, B.Sc., A.I.C.). Each of these gentlemen is well known as an authority in the subject he has dealt with, and the book has been given enhanced value as a result of their contributions.

Among the other important matters which are dealt with are the modern tungsten alloys for acid resistance, tungsten springs for use at elevated temperatures, and the use of this metal for electrical contacts. Data regarding physical properties have been brought up to date, and the equilibrium diagrams have, where necessary, been revised in accordance with the most recent published researches.

References are given on the pages on which they are mentioned, instead of being relegated to the end of the chapters; the book is well indexed, and, in spite of its highly technical nature, is very "readable." It deserves a wide circulation, both among those academically interested in tungsten, and the large number of engineers who use it in one form or another.

N. L. E.

DR. EDWIN GREGORY is relinquishing his position as lecturer in metallurgy at the University of Sheffield, to take up the duties of chief metallurgist to the Park Gate Iron & Steel Company, Limited, Rotherham. Dr. Gregory has been on the University staff for 17 years, and previously had 12 years' industrial experience with Keyser, Ellison & Company. He has made several contributions to technical literature.

Origin of the Izod Test

Matters of considerable historical interest were revealed during the Symposium on Notched-Bar Impact Testing recently held in Manchester, when the Chairman (Mr. F. O. Chorlton) called upon Dr. Izod to address the meeting. Dr. Izod, it will be remembered, was the originator of the well-known test bearing his name.

DR. IZOD said he very much appreciated the honour which had been paid him by inviting him to attend the Conference. He would preface his remarks by stating that he knew nothing whatever about the impact test. He did not know whether those present knew any more than he did, but as he appeared to have been the person who started the trouble perhaps he might be spared a few minutes of their time while he explained how the whole thing commenced. In 1903 he was steel testing for Captain Robinson (Willans & Robinson), at Rugby. He was asked to test a gun barrel which had burst and killed two men as a result. Material from the burst gun barrel was supplied, and also material from gun barrels which had not burst. He cut samples from both, took stress-strain diagrams, and made every test he knew. Both types of material appeared to be precisely similar; so he scratched his head and wondered what was wrong. Then he filed up two specimens with his own hand, $\frac{3}{4}$ in. wide, $\frac{7}{16}$ in. thick, and cut a notch in them. He marked them in such a way that he should not know which he was testing, and his assistant, Mr. Marshall, placed them in a vice and broke them with a hammer. One broke off like a carrot, while the other one required about five blows to break it. He then came to the conclusion that he was an awfully clever fellow who had discovered something quite new.

Continuing, the speaker said that at the time he knew nothing whatever about the work of Frémont or Charpy, but that was ignorance. Then he developed a pendulum type of machine, and made more tests. So far as Willans & Robinson were concerned those tests solved a considerable number of their problems in respect of breakage of materials. The idea was patented though it was not really a valid patent. A circular was sent to all his engineering friends and firms concerning it, and he received no replies thereto. He did, however, have the privilege, as a youngster, of associating with some very famous engineers interested in steam turbines and thermodynamics, etc., such as Capt. Sankey, Mr. Ferranti, Sir Charles Parsons and Professor Unwin. All of them gave him an extraordinary amount of encouragement. Nothing was done for 20 years. He went as an engineer to the gold mines in South Africa, and forgot all about it. Then his friend, Mr. Barry, came out to South Africa, and informed him that his Izod test had solved many special problems.

In conclusion, he hoped that the Conference would have a very interesting discussion. Those who were taking part in it so far were certainly talking far above his understanding. He left engineering about 15 years ago and went on to finance, which was not nearly as interesting. There was one complaint he had to make against all the speakers that afternoon. His name was not pronounced *I*-zod; it was Iz-od.

Copper Stocks—A Parliamentary Reply

The PRESIDENT OF THE BOARD OF TRADE, replying to a question, said that stocks of copper in public warehouses in the United Kingdom on December 4 were 29,055 tons. The supply position of copper, as of other essential commodities, in relation to a national emergency, was under constant review. There was a large production of copper within the Empire, in which both British and foreign interests participated.

Naturally-Bonded or Synthetic Moulding Sands?*

By A. TIPPER, B.Sc.

One very important aspect of the progress in the mechanisation of foundry operations is the planning or perhaps the re-organisation of foundries, and it is thought that those men on whom this responsibility falls cannot neglect the question of sand. What type of sand is to be used? Which will be most economical? Which will give a minimum of scrap castings? And so on. The possible field includes green-sand, dry-sand or oil-sand moulding, but the main choice really lies between naturally-bonded and synthetic sands.

To some extent the decision will depend on the particular circumstances of the foundry, but an endeavour will be made to show, in this Paper, what is actually being done in various British foundries to-day, both with natural and synthetic sands, in the hope that this information will assist those whose ideas on the subject are still vague, in any decision they may have to make.

So many Papers dealing with sands are now appearing both abroad and in this country that it is difficult to keep up-to-date with published work. For those particularly interested in synthetic sands a short list of contributions to this subject which have appeared within the past 12 months or so has been drawn up for reference. It is considered, however, that one can still look back with pride to the Paper given to the Institute in 1933 by Sheehan ("Recent Developments in British Synthetic Moulding Sand Practice"), as an outstanding contribution on the subject. In that Paper Mr. Sheehan dealt with his own particular problems as typical of the day. That was more than three years ago, and since then other foundrymen in this country have been confronted with somewhat similar problems. Such problems include the demand of the engineer for castings with narrower limits of accuracy, smaller machining allowances and greater uniformity, and a natural desire for lower scrap losses and greater output. These problems can be solved, and are being solved, though not always in the same way.

American Practice

In America, the home of synthetic-sand practice, most steel, iron and malleable iron foundries use a synthetic sand. This is in part due to the lack of good deposits of natural moulding sands, which no doubt fostered the early growth of synthetic-sand practice, but the successful and continued use of this sand argues well for the suitability of such sands in general. As in this country, cost is a prime factor, and local sands are used if possible to avoid freight charges.

The author has been able to obtain a few details of the cost of sands in America (set out later) which show that the difference between the two countries is not very great, except that silica sands in America are nearly as cheap as our moulding sands. Non-ferrous foundries in America use mainly natural bonded sands if obtainable locally. With the introduction of American methods of production, mechanisation of foundries and the employment of semi-skilled labour, sand control became very necessary in order to obtain consistent results, and in the search for further improvements synthetic sands were tried.

How far these have proved successful in certain British foundries has already been stated in Papers to the Institute by F. Hudson, Sheehan, Shepherd, and T. R. Walker. Naturally, changes of this sort are rather slow, for it is only when some big change or development takes place in a foundry or serious trouble is encountered with sand that an alteration is visualised.

In this country, as far as can be gathered, there are roughly between 2,700 and 3,000 foundry concerns (including steel, cast iron, malleable and non-ferrous). Of these approximately 30, or 1 per cent., are using synthetic-sand practice, either wholly or in some section of the foundry. Additionally there are two foundries using cement-bonded sand.

Constitution of Sand

By synthetic sand is meant a moulding sand built up from a selected silica sand or other sand and a suitable bonding agent. The three main constituents of a moulding sand are (1) the sand grains, (2) the bonding material, and (3) moisture. All three are of primary importance in determining the characteristics of the sand, but whereas with natural moulding sands one can control and adjust to some extent items (2) and (3), with synthetic sands all three constituents are carefully selected to give the desired properties, and are controlled within fairly close limits.

Sand Grains

Everyone is familiar with the type of sand grains (Fig. 1) found in sea sand or other bondless silica sands, which have been scrubbed free of other mineral matter by water and wind action, becoming in the process more or less rounded and worn. In natural bonded sands these grains also make up perhaps 90 per cent. of the sand, the remaining 10 per cent. being composed of disintegrated mineral matter, associated with the quartz or silica grains. These grains (Fig. 2) form the porous structure of the sand and, according to their size, shape and surface condition, determine the permeability and materially affect the moulding properties of the sand.

The sand grains from natural moulding sands are not usually rounded or worn to anything like the same extent as with a sea, river or desert sand, whilst their grading or size is much more varied, *i.e.*, not classified.

When examining a sand, a picture is formed of the distribution of the various sizes of grains from the results of a sieve test. This is a very

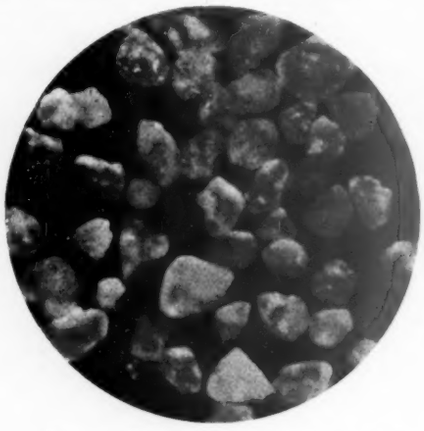


FIG. 1.—TYPICAL MICROSTRUCTURE OF BONDLESS SAND.

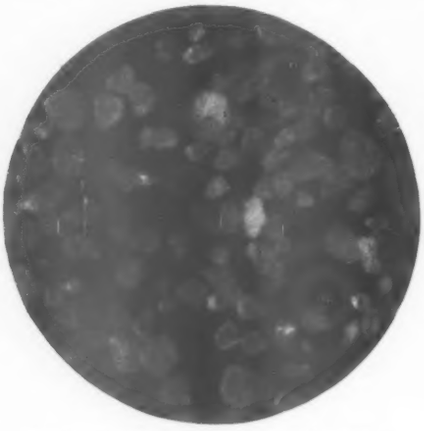


FIG. 2.—MICROSTRUCTURE OF NATURALLY-BONDED SAND.

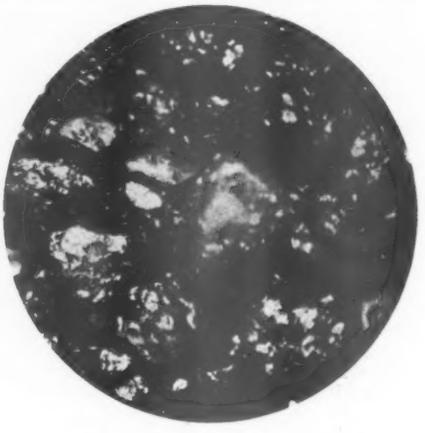


FIG. 3.—MICROSTRUCTURE OF AN IRREGULAR-GRAINED SAND.

TABLE I.—*Grading of Natural Bonded Moulding Sands. Sieve Tests on Washed Sands (Clay Free).*

Type of sand.	Mansfield red.	Bromsgrove red.	Midland red.	Wombourne red.	Wolverhampton red.	Blankshire facing sand.*
Per cent. remains on—						
30 mesh	—	—	—	—	—	—
40 ,, ...	1.0	1.2	1.0	1.6	2.9	11.2
60 ,, ...	1.9	5.8	7.3	6.6	6.2	8.2
80 ,, ...	2.8	9.2	16.3	9.4	1.4	7.2
100 ,, ...	6.7	14.0	18.1	16.2	11.3	9.5
120 ,, ...	2.7	4.5	5.3	4.9	3.0	3.2
150 ,, ...	27.2	23.6	21.7	27.1	27.2	23.6
200 ,, ...	28.9	12.2	10.6	9.1	14.2	12.8
Passes 200 mesh	18.0	18.4	14.5	17.0	23.5	12.1
Clay, per cent. (A.F.A. method)	10.5	11.1	5.1	7.9	10.3	12.3†

* This sand gave unsatisfactory finish. † Includes coal-dust.

* A Paper read before a joint meeting of the Birmingham and London Branches of the Institute of British Foundrymen, Mr. H. J. Roe presiding.

important test, and it has now been agreed both by the Iron and Steel Institute Moulding Materials Sub-Committee, and the Institute of British Foundrymen Sands Committee to standardise on a series of sieves. These are the B.S.S. Nos. 8, 10, 16, 22, 30, 44, 60, 100, 150, 200 and 300. It is known that the permeability of a sand decreases as the size of grains decreases, and that as the size of grains decreases the surface area of grains in a given volume of sand increases, so affecting the bond or strength; but it is probably not realised to what a marked extent the distribution of various sized grains affects the properties of the sand. This has been clearly shown by an American contributor, Mr. G. K. Eggleston, in a recent Paper on "Non-Ferrous Sands."

TABLE II.—*Grading of Silica Sands used as a Basis of British Synthetic Moulding Sands. Sieve Tests (Unwashed Sand.)*

Type of sand.	Sea sand, Southport dune sand.	Leighton-Buzzard medium.	Erith silica.	King's Lynn silica.	Leighton-Buzzard bank sand.	Ryarsh silica.
Per cent. remains on—						
30 mesh	Less than 0.1	6.3	1.0	6.4	1.5	—
40 ,, ...	0.7	20.0	8.6	13.4	—	0.5
60 ,, ...	26.7	50.5	49.4	34.6	32.3	0.8
80 ,, ...	39.9	15.2	26.9	26.3	26.6	2.1
100 ,, ...	27.3	4.5	10.7	13.0	—	1.5
120 ,, ...	2.9	2.4	1.0	1.8	29.3	0.7
150 ,, ...	2.0	0.5	2.0	3.6	7.5	66.9
200 ,, ...	0.5	0.4	0.5	0.4	1.8	18.7
Passes 200 mesh	—	—	v. small	0.5	1.0	8.8
Clay or silt, per cent. ..	—	—	—	v. small	0.6	up to 1.5 (varies)
Loss on ignition, per cent. ..	0.8	Less than 0.1	Less than 0.1	0.25	—	—

The *surface condition of the grains* which, together with the surface area, affects particularly the bonding properties or strength of the sand (Fig. 3), and *the expansion characteristics*, are particularly important. Since one can regard all sand grains as having approximately the same expansion characteristics, the difference in behaviour of a mould when subject to heat depends on such factors as the density of the mould (*i.e.*, packing of the grains), and the presence of materials which will give way or afford room for the increased volume of the quartz grains, so avoiding buckling or distortion of the mould face. Obviously, when a sand is made up of a great variety of sizes of grains or a high proportion of fine grains, the effect of expansion is more difficult to overcome.

At this point it is appropriate to compare the grain size and distribution of typical natural bonded moulding sands with those sands used in synthetic-sand mixtures. Until recently the natural bonded sands were chosen as a result of practical trials from deposits of widely differing types—in Scotland the rotten rock sands; in Northern England the yellow sands of Yorkshire or red sand from Worksop or Mansfield; in the Midlands one of the numerous Bunter red sands, and in the South the light yellow or grey loamy sands of London or Southampton districts. Each particular type has certain features of its own, although there is a general similarity between all red moulding sands which makes them of general use, except for steel moulding, all over the country.

In a recent questionnaire issued by the Institute's Sands Committee, red sands were used in 35 out of the 84 facing mixtures examined. These include mixtures for cast iron, non-ferrous and malleable work.

Table I gives details of sieve tests made on a number of naturally bonded sands used in Midland iron foundries for green-sand moulding. Note particularly the way in which the grains are spread over the whole range of sieves from 60 to 200, with considerable percentage passing 200 mesh. (It should be mentioned that all the test results shown have been made on Tyler IMM. standard sieves, and should not be confused with the new British standard sieve sizes.)

Compare now the grading of silica sands used as the basis of synthetic-sand mixtures used in this country (Table II). It will be noted how the bulk of grains in each sand occurs between two or three sieve sizes, and that, apart from Ryarsh, they are all graded between the 60 to 120 sieves. The SiO_2 content varies from 97 to 99.5 per cent.

Before arriving at any conclusion, a consideration of the other two components of the sands as used is worth while.

Bonding Material

The natural bonding material of sands is formed by clays of varying composition and physical properties, together with other mineral matter, such as limonite (hydrated iron oxide), which is often present, adhering to, or coating the particles of clay and quartz grains. The proportion of bonding material present in a deposit of moulding sand varies considerably, but the sand can be graded to give a fairly uniform amount of bonding material, and some of the best deposits show surprisingly little variation over long periods, as shown by the sieve test and clay content.

Recent investigations of the physical and chemical properties of bonding clays, both in America and in this country, by the B.C.I.R.A. have shown that much depends on both the chemical nature and the physical characteristics of the minerals in the bonding substance.

To summarise briefly, the conclusions are as follows:—

The green strength of a moulding sand, apart from such factors as grain size, moisture, milling and percentage of bond, is dependent on the particle size of the bond.

The dry strength is dependent on both chemical and physical properties of the bond and can be correlated with the base exchange value of the sand. This value expresses the ability of the sand or other material to hold either basic or acid ions* on their surface. Owing to the great surface area of bentonite, this property can be increased or decreased by the addition of alkalies or acids.†

The life or property of the bonding substance to be rehydrated after exposure to elevated temperatures (so recovering its plasticity) varies with the type of minerals present in the bonding substance.

TABLE IV.—*Moulding Sands used for Cast Iron in British Foundries, showing Variation in Composition and Properties.*

Type of Casting.	Ratio new sand to old.	Ratio coal-dust to sand.	Moisture per cent.	Green compression str. lbs. per sq. in.	Green permeability A.F.A. No.	Dry compression str. lbs. per sq. in.
Light—						
Minimum	1–100	1–500	3.5	2.4	22	24
Maximum	1–1	1–5	8.0	6.5	46	100
Average	1–3	1–35½	6.0	4.8	30	70
Medium—						
Minimum	1–40	0	3.5	3.1	16.5	25
Maximum	1–1	1–50	7.0	10.0	53	200
Average	1–3½	1–18½	6.75	5.0	31.3	90
Heavy—						
Minimum	1–12	0	3.5	4.5	20	50
Maximum	2½–1	1–19	8.0	9.5	60	162
Average	1–2	1–15	6.75	5.8	35	95

Other Cardinal Points

Taking a sand consisting of all 40-mesh grain with a permeability of 500 A.F.A., and a second sand consisting of all 270-mesh grain with a permeability of 40 A.F.A., the addition of 10 per cent. of the 270-mesh material to the 40-mesh grain reduces the permeability to 100, and the addition of 15 per cent. of a 140-mesh material to the 40-mesh reduces the permeability to 150. To compare with these figures, the permeability of cores made from Southport sea sand is 140 A.F.A.; King's Lynn sand, 165 A.F.A., and Ryarsh silica sand, 60 A.F.A.

TABLE III.—*Natural Bonded Sand Mixtures used in Midlands for Cast Iron—Green-Sand Moulding.*

Type of sand.	Proportion of new sand used.	Class of work.	Moisture per cent.	Green compression str. lbs. per sq. in.	Green permeability A.F.A. No.	Dry compression str. lbs. per sq. in.
	Per cent.					
Mansfield red ..	8–9	General engineering	6.0	3.1	25	41.5
Bromsgrove red ..	unit sand 1 per cent. 0.2 C.D.	Small electrical fittings	6.0	5.2	30–40	80–85
Midland red ..	25 3 C.D.	General engineering	5.5	7.1	23.3	73
Wombourne red ..	10 5 C.D.	Medium wt. valves ..	5.5	5.0	38.5	—
Bromsgrove red ..	17 3 C.D.	Small castings high duty iron.	5.5	2.7	41	40
Stourbridge red* ..	35 6 C.D.	General engineering up to 10 cwts.	6.8	5.3	16.5	121
Wombourne red ..	33 6 C.D.	Stove plate for enamelling	4.2–4.5	4.6	22	—
Harborne red* ..	33 8 C.D.	Machine tools small and medium wt.	6.7	5.0	26.4	94

* Hand moulding.

* Atoms or molecular groups of atoms carrying a charge of electricity.

† The addition of small proportion (0.5 per cent.) alkali to a dispersion of bentonite in water, materially influences its viscosity.

The bonding substances can be roughly divided into three groups:—

(1) *Bentonite Clays.* Here the particle size is less than 1 micron. diameter, which is extremely small. The green bonding value is very high, the base exchange value being 100. Its chief constituent is Montmorillonite, that is a hydrated aluminium silicate. Its life is very good, rehydration taking place up to 540 deg. C., whilst the refractoriness is fairly good, being of the order of 1,300 deg. C.

(2) *Kaolinite Clay Substance (including silicious clays).* The chief constituent of Kaolin or China clay type is hydrated aluminosilicate, which is also the constituent of many plastic clays and fireclays. Its particle size varies widely, reaching up to 20 microns. The green bond varies, and may be improved with continued use owing to subdivision of clay particles. The refractoriness is very high, but varies up to 1,650 deg. C. Its life is only fairly good, rehydration taking place up to 426 deg. C.

(3) *Limonite* or hydrated iron oxide may be ferrous or ferric, but generally is given the formula of $2Fe_2O_3H_2O$. It occurs as a coating or staining on grains but it can also occur in a colloidal form, and gives improved green and dry strength in the presence of other plastic bonding clays. Its refractoriness is comparatively low owing to fluxing effect of iron oxide with silica forming a ferrous silicate slag. Its life is poor and rehydration takes place up to approximately 180 deg. C.

Expansion Characteristics

The expansion characteristics of clays vary. Some clays begin to contract at high temperature and so may cause failure of a mould face. In British sands, the bonding substance is often a mixture of types 2 and 3, though the exact mineral nature is very difficult to identify. With a few exceptions the bond of these sands is not sufficiently refractory for steel moulding practice; hence the use of Continental sands and "compo" mixtures.

However, there are a few British deposits of clays which are both refractory and sufficiently plastic to act as bonds in synthetic sand mixtures. These are the ball clays or plastic clays occurring in the South of England, to a very limited extent. The chief available bonding substance with one exception is the imported American bentonite (sold under trade names).

The use of such substances with very high bonding properties and good life enables most economical proportions to be used in synthetic mixtures, at the same time developing equal or higher bonds than obtained from natural sands. In Table III particulars have been tabulated of a number of facing sand mixtures, using naturally bonded sands, as used in the Midlands for a variety of work in cast iron. Note the physical characteristics of these sands. The moisture is roughly 5.5 to 6.5 per cent.; the green bond 5.0 lbs. and the permeability 20 to 40 A.F.A. Note also the wide variation in proportion of new sand used in these mixtures.

When comparing naturally bonded sands used in various parts of the country, one is impressed by the tremendous variations both in proportions of new sand to old, and also in the physical properties of the mixtures, as is shown in Table IV. It is obvious that the satisfactory results obtained can only be attributed to the skill and local experience of the moulders with that particular mixture. Any attempt to standardise procedure with such a variety of mixtures would be disastrous.

The "Z" Bulletin

Messrs. J. H. Fenner & Company, Limited, Hull, have sent us a copy of the first issue of the "Z" Bulletin, a bi-monthly publication dealing mainly with patented "Z" dressed solid woven rubberised beltings all through. It is, however, also something of a house organ without the usual advertisements other than those of the firm.

Uncertain Copper Outlook

BY "ONLOOKER."

The disastrous fall in copper which began in March last has resulted in the price of the metal being very nearly halved, and at the time of writing it is by no means certain that a further decline will not take place. A further setback, if it should take place, is not likely to go very far, and it is perhaps significant that for some weeks now—to be exact, since electro dropped to £43—a much steadier tone has been apparent, with sellers far from eager at the ruling level. This is a rather puzzling fact, for at the current rate of buying the world's daily production is not being cleared, and one would almost have expected producers to hedge their unsold balance on the London Metal Exchange.

Probably a certain amount of this is being done, but a lot of copper is being held at risk, presumably because producers look for an improvement both in the price level and in the volume of demand. Consumers are holding off, partly because there has been a seasonal decline in business and partly because the uncertainties of the situation are such that they have preferred to draw on stocks and await events. In the States the call for copper is down to a minimum, and deliveries are averaging about 1,000 tons a day.

Recent official figures released in New York suggest that the cut in output instituted by some of the American producers is already having its effect, but the falling-off in the rate of consumption has been so severe that little or no benefit has accrued. Outside the United States curtailment is taking place also, but it only began on December 1 last and will hardly do more than compensate for the somewhat lower rate of use which will probably be experienced during 1938. Moreover, it is going to take time for this cut in output to have an effect on the situation, and in the meanwhile there is plenty of copper available and stocks are growing. As a matter of fact, the failure of the price to achieve any sort of a convincing rally has so disturbed the bull faction that there is now talk of a possible further cut in production, a step which, if seriously undertaken, might bring unexpected developments.

The International Tin Committee recently announced a 40 per cent. reduction in the quota for the first quarter of 1938, but the market took the news very coolly, and actually there was a small decline instead of the runaway upward movement which was expected in some quarters. Presumably the action was interpreted as meaning that prospects for tin consumption in the New Year were not too good, and it is the writer's opinion that a similar step by the copper people would be more likely to cause alarm than promote confidence in the immediate outlook. It is obviously very difficult to know how the market will take these things.

Those who believe that copper is on the eve of a rally point out that consumers on both sides of the Atlantic have been holding off and that a buying movement is long overdue. The writer would not care to pin too much faith to the likelihood of a rally in the price from this cause, for users of the metal are in a somewhat chastened frame of mind, and bearing last year's events in mind they are likely to follow a cautious policy for some time to come. Actually it seems much more likely that for some months the quotation will keep near the present level, with minor fluctuations on either side of £40 for standard. Developments in the States must, however, be watched, for it is possible that the custom smelters may drive the price below 10 cents in their anxiety to make sales. Should this happen some setback in London would be inevitable, for operators on this side still watch New York very closely, and the two markets do on the whole march in step.

The Production of Some Intricately-Cored Iron Castings

(*Concluded from page* 487.)

A Cylinder Block Casting

A further example, and one that illustrates the modern trend towards the elimination of separate components and the incorporation of a large number of pieces in one casting, is illustrated in Fig. 7. It shows the cylinder block of a compressed-air engine, and as will be seen from the illustrations it is a twin cylinder of the trunk type with the cylinders at an angle—sometimes known as a "Vee" engine. This particular casting embraces two cylinders, the valve chest for rotary valve, the air ports, the crankcase and the air inlet and filter chamber. The mould is jointed through the centre line of the cylinder and the assembly of cores is a fairly straightforward matter.

The feet cores are first assembled, then the air inlet core and the filter chamber core.

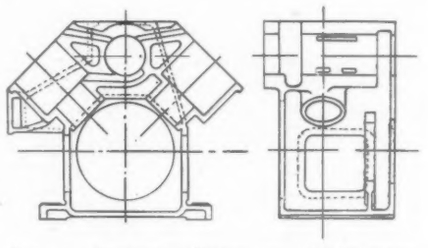


FIG. 7.—CYLINDER BLOCK FOR COMPRESSED-AIR ENGINE.

Next the half of crankcase core is assembled in the bottom mould and into this the cylinder-bore core and two small lightening cores are placed, while over these the top core forming the crankcase portion is assembled. The separate core forming the chamber in which the gear wheels driving the valve are contained is then assembled, and the top lowered in position. The set of cores forming this casting are straightforward and are made of a sea-sand mixture. The job is run into one of the feet on the joint, and is a typical example of the complicated type of casting which engineering design now demands from the foundry.

Catalogues Received

Fans. The object of publication K1, just issued by Keith Blackman, Limited, of 27, Farringdon Avenue, London, E.C.4, is to announce that fans in which the "Keith" multivane impeller is fitted are now obtainable in two distinct types, namely, the original "Keith" fan and a later development, the E.K. fan. The outstanding difference is that the newer model has an outlet of approximately the same area as the inlet, the older one being of the order of three-quarters. Full performance details are listed, as well as other germane information.

"Wimet." List No. 8, recently issued by A. C. Wickman, Limited, of Coventry, covers an extremely wide range of "Wimet" (formerly Widia) tips for tools. "Wimet," it will be remembered, is a cemented tungsten carbide, the cement being a matrix of cobalt. It is largely used by the chilled-roll section of the foundry industry, but its use is extended to all types of cast iron.

RIDSDALE & COMPANY, LIMITED, of 3, Wilson Street, Middlesbrough, have made arrangements with the H. W. Dietert Company to manufacture in Great Britain the latter's various lines of sand-testing equipment, most of which has been standardised by the American Foundrymen's Association

A Film

"WORKINGTON Acid Bessemer Steel Rails"

is now available on loan to Railway and other Engineering Societies. The film is on 16mm. silent non-flam stock, is 400ft. long and takes 15 minutes to show. It is self-contained with explanatory titles, and shows the manufacture of steel rails from pig iron to the finished produce. It includes:—Blast Furnace—Acid Bessemer Process—Casting Ingots—Rolling—Sandberg Sorbitic Treatment.

For available dates, please apply to the Publicity Department, The United Steel Companies Ltd., 17, Westbourne Road, Sheffield, 10.

THE UNITED STEEL COMPANIES LTD

W.36

The Week's News in Brief

Trade Talk

THE NEW FOUNDRY which R. A. Lister & Company, Limited, are building at Dursley is now nearing completion.

THE FOURTEENTH Annual Refractories Association Ball will be held on January 14 at the Royal Victoria Hotel, Sheffield.

A PARTY OF sixty members of the Derby and Derbyshire Chamber of Commerce recently visited the works of Aiton & Company, Limited, engineers and ironfounders, of Derby.

THE FIRM of Hardie & Gordon, iron and brass founders, of Levenbank Foundry, Dumbarton, have been granted warrant by the Dean of Guild Court to re-erect the existing No. 1 foundry and extend it by 90 ft.

THE BRITISH OXYGEN COMPANY, LIMITED, with its associated concerns staged the annual staff dinner and dance at Grosvenor House, London, last Friday. The function, which ranks as one of the largest of its kind held in London, was admirably organised.

THE ANNOUNCEMENT that large numbers of timber houses are to be erected in various parts of Scotland has been welcomed by the light-castings industry, employment in which, it is reported, has been curtailed because of the hold-up of housing schemes. These timber houses will, of course, call for the usual quota of pipes, stoves, grates and other domestic light castings.

THE STANTON IRONWORKS COMPANY, LIMITED, which holds the whole of the 150,000 " B " ordinary shares of the Wellingboro' Iron Company, Limited, is offering to acquire the remaining issued shares. The offer is one £1 Stanton ordinary for every five £1 Wellingboro' " A " share, and one £1 Stanton 6 per cent. cumulative preference share for every one £1 Wellingboro' 7 per cent. cumulative preference share.

THE WORSHIPFUL COMPANY OF FOUNDERS held their Livery dinner in London last Thursday. The Lord Mayor and the Sheriffs of the City of London were the principal guests, and among those present were Mr. W. R. Barclay (President of the Institute of Metals), Mr. W. Christopher, Mr. G. T. Lunt, Brig.-General Magnus Mowat, Mr. J. G. Pearce (British Cast Iron Research Association), and Sir John Thornycroft (President of the Institution of Mechanical Engineers).

REPRESENTATIVES OF the Treasury and the Export Credits Guarantee Department of the Board of Trade have just visited Turkey, where about 50 British constructional engineers are at present supervising the construction of the £3,000,000 Turkish iron and steel works at Karabuk by local labour. A number of Turkish students are being trained in this country to occupy positions on the staff of the new works. The foundations of the new buildings have been laid, and in a few months construction will have advanced far enough for the installation of the plant. Production is expected to start about the end of next year or the beginning of 1939. The output of the works will be mainly absorbed locally in the building of railways, docks, mines, roads and factories.

ON DECEMBER 10 Mr. A. W. Swan, of the United Steel Companies, Limited, showed a party of guests some technical films in colour at the company's London office in Grosvenor Gardens, Westminster. These included the mining of iron ore, coke-oven work, blast-furnace practice, acid-Bessemer blowing, open-hearth shops, casting, teeming, stripping, reheating, rolling, etc., all the " shots " being made on the company's properties. Some very interesting shots were also shown taken at night with only the light emitted in normal operations. The results were very satisfactory, even to the final pass of a rail and the hot-sawing operation. Mr. Swan claimed to be first in this country to show a complete colour film dealing with steel, having done so at the Foundry Exhibition in London this year. Some other non-technical films, also in colour, were included in the programme. It was intimated that the technical films may be borrowed for use at meetings of various societies.

A NUMBER OF ENGINEERING SOCIETIES have decided to co-operate in organising an International Engineering Congress in Glasgow next year, to be held during the progress of the Empire Exhibition, Glasgow. A representative General Committee has been formed, with the Rt. Hon. Lord Weir, P.C., G.C.B., as President. The Congress will be held from June 21 to 24 inclusive, and during these dates an interesting programme has been arranged, which includes an opening session in the Conference Hall of the Exhibition, a civic reception, technical sessions, visits to the Exhibition and works in the district, and alternative excursions by river and into surrounding country. During the technical sessions addresses will be delivered by outstanding authorities on each branch of engineering. Membership of the Congress will be open to members of any recognised technical society. A fee of £2 5s. will be payable by each member and £1 15s. for an accompanying lady, which will include : Attendance at Congress, excursions, receptions, etc., admission to the Exhibition, and volume of proceedings for each member. A definite and detailed programme is in course of preparation. Mr. P. W. Thomas, of 39, Elmbank Crescent, Glasgow, C.2, is the Hon. General Secretary.

THE L.N.E.R. PROGRAMME FOR 1938 provides for the construction of 125 locomotives, 730 carriages, 10,240 wagons, 1,250 containers, and the renewal of 587 miles of track and 70 bridges. The company has placed some important contracts for the supply of carriages, wagons and containers. These contracts provide for the construction of 234 coaches, 155 20-ton coal wagons, 100 40-ton timber wagons, and 900 containers. The contracts have been placed with the following firms:—Cravens Railway Carriage & Wagon Company, Limited, Sheffield (350 containers, 24 carriages); Metropolitan Cammell Carriage & Wagon Company, Limited, Birmingham (550 containers, 104 carriages); Hurst Nelson & Company, Limited, Motherwell (155 20-ton coal wagons); R. Y. Pickering & Company, Limited, Wishaw (100 40-ton timber wagons); Birmingham Railway Carriage & Wagon Company, Limited, Birmingham (106 carriages). The L.N.E.R. announce that in connection with the Manchester-Sheffield-Wath electrification scheme, a contract has been placed with the Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester, for the design, manufacture and erection of 70 complete electrical equipments required for 70 mixed traffic electric locomotives. They will be suitable for the overhead line conductor system, using direct current at 1,500 volts. These locomotives will be of the four-axle double-bogie type, and it is estimated that they will weigh 80 tons each, and that the horse-power will be approximately 1,850.

Personal

COMMANDER SIR CHARLES CRAVEN, managing director of Vickers-Armstrongs, Limited, has been re-elected chairman of the Industrial Welfare Society.

MR. NORMAN BRUCE, who has acted as London representative for Shaw Glasgow, Limited, of Maryhill Iron Works, Glasgow, for the past eleven years, has been appointed joint managing director of the company as from January 1 next.

MR. HENRI STRUBE, President of the Chambre Syndicale des Fonders en Cuivre et Bronze de France, has been elevated to the grade of Officer of the Legion of Honour, as a recognition of his sustained interest in technical education.

MR. C. W. BIGG (President of the Institute of British Foundrymen, and assistant managing director of Qualcast, Limited); Major J. M. Aiton and Mr. E. G. Boissier (directors of Aiton & Company, Limited); Mr. E. W. Hives (Rolls-Royce, Limited), and Captain G. S. Bellamy (L.M.S. Locomotive Works) have been appointed patrons of the Derby Society of Engineers.

Obituary

MR. WILLIAM MITCHELL, who retired 3 years ago from the position of foreman enameller with Smith & Wellstood, Limited, Bonnybridge, has died at the age of 75.

THE DEATH of Dr.-Ing. E. L. Lebrecht Steinmüller, one of the most prominent industrialists of the Rheinland, is recorded by our contemporary, " Die Giesserei." He was governing director of L. & C. Steinmüller, of Gummersbach, a business previously controlled by his father.

Contracts Open

Worthing, January 3.—Iron castings, for the Town Council. Mr. P. E. Harvey, borough engineer, Town Hall, Worthing.

Lampeter, January 17.—Provision and laying of 1,500 yds. of 4-in. dia. cast-iron spun pipes, for the Town Council. Thomas & Morgan & Partners, engineers, Pontypridd. (Fee £2 2s., returnable.)

South Africa, January 24.—90-ft. electrically-driven turntable, complete with motor, for the South African Railways and Harbours Administration. The Department of Overseas Trade. (Reference T.Y. 28930/37.)

Driffield, January 11.—Construction and erection of electrically-driven pumping machinery, for the Rural District Council. Mr. C. B. Newton, consulting engineer, Burnett Avenue, High Street, Hull. (Fee £5, returnable.)

Pembroke, January 4.—Provision and erection of four electrically-driven pumping sets all in duplicate, and one oil-engine-driven standby unit, for the Town Council. A. P. I. Cotterell & Son, engineers, 54, Victoria Street, S.W.1. (Fee £2 2s., returnable.)

Bridgnorth, January 8.—Supply and erection of electric pumping machinery, comprising two sets of vertical-spindle borehole centrifugal pumps and booster pumps, each set being driven by an electric motor on the same vertical shaft with suction and delivery piping (each unit to deliver 25,000 galls. per hr.); supply and erection of two sets of electrically-driven horizontal booster pumping sets, each set comprising horizontal spindle-type multistage centrifugal pump and motor, suction and delivery piping, air compressor, tank and interconnecting pipes (each unit to deliver 3,000 galls. per hr.), for the Town Council. W. H. Radford & Son, consulting engineers, Albion Chambers, King Street, Nottingham. (Fee £3 3s., returnable.)

Richard Thomas and Armco

Richard Thomas & Company, Limited, announce that they have contracted with the American Rolling Mill Company, of Middletown, Ohio, U.S.A., to purchase from them, as from July 5 next, all the shares issued by Armco, Limited, a company incorporated in England under the Companies Acts. The business carried on by Armco, Limited, was established in this country some 15 years ago, and it is stated that its registered brand " Armco " will be available for specialities produced by Richard Thomas & Company at their works and sold exclusively through Armco, Limited, which will continue to trade as hitherto. Armco has been working in this country with John Summers & Sons, Limited, but this arrangement ends on July 2, 1938. The American Rolling Mill Company is the company from which Richard Thomas & Company purchased the sole rights in this country of their strip mill process. It is announced that the American Rolling Mill Company have also entered into a contract which places the benefits of their American research department at the disposal of Richard Thomas & Company, and in addition gives Richard Thomas & Company the right to send members of their organisation for training in the American Rolling Mill Company's American works and the right to manufacture all grades of steel made by that company's processes, and binds that company to work exclusively with Richard Thomas & Company in this country and to lend their experts to Richard Thomas & Company.

Publication Received

Team Valley Trading Estate. Without hesitation we designate the latest brochure to be issued by the Team Valley Trading Estate the most intelligently compiled publication of its kind we have ever received. It is specifically designed to attract new industries to the locality, and the business man has two prime requisites in this matter, namely, that all the essential information such as the local conditions which affect overheads and costs of production should be indicated, and that the publicity matter should be attractively presented. Both these conditions have been well satisfied, and we certainly congratulate the officers responsible.

TOR ROCK SAND
for the
FOUNDRY

Higher casting temperatures in iron foundries—particularly in those where special alloys are melted—have resulted in a demand for a moulding sand to withstand severe conditions and produce sound castings of good finish. Tor Rock Sand has proved to be specially suitable for these requirements. It is coarse in grain and highly permeable and being somewhat irregularly graded, tends to give a strong and compact mould surface.

Please write for full particulars and sample to the nearest sales office:

GENERAL REFRACTORIES LIMITED
GENEFAX HOUSE, SHEFFIELD.

Telephone: 31113 (6 lines).

Telegrams: "Genefax, Sheffield."

LONDON OFFICE: Russell House, Adelphi, W.C.2. Telephone: Temple Bar 3511. Telegrams: "Genefax, Rand-London." (Mr. A. C. Turner).

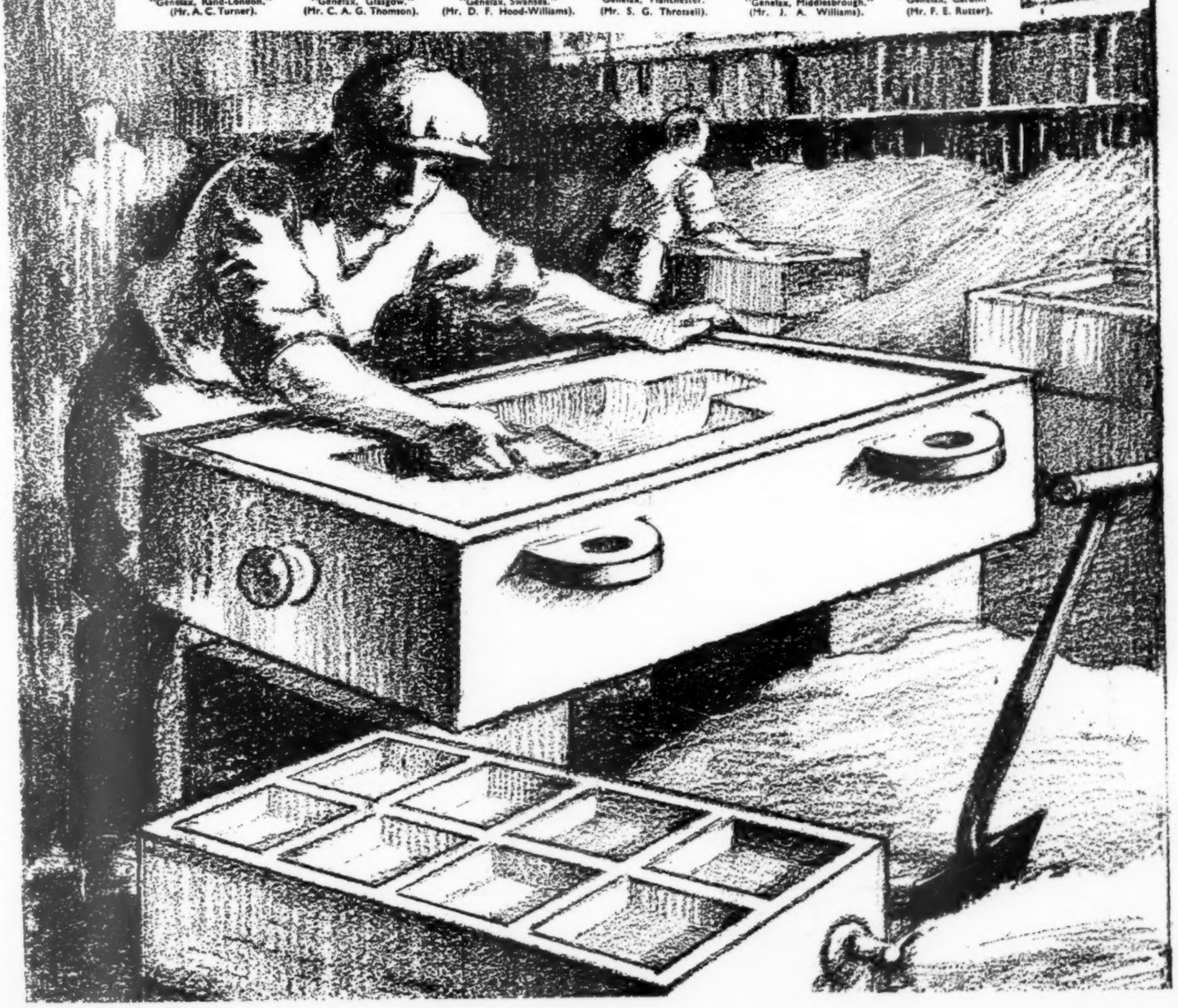
SCOTTISH OFFICE: 48, West Regent Street, Glasgow, C.2. Telephone: Douglas 6108 (3 lines). Telegrams: "Genefax, Glasgow." (Mr. C. A. G. Thomson).

SWANSEA OFFICE: Metropole Chambers, Wind Street. Telephone: 3680. Telegrams: "Genefax, Swansea." (Mr. D. F. Hood-Williams).

MANCHESTER OFFICE: 9, Albert Square. Telephone: Blackfriars 6130. Telegrams: "Genefax, Manchester." (Mr. S. G. Throssell).

HIDDLESBROUGH OFFICE: Halifax Bldgs, Exchange Place. Telephone: Middlesbrough 3313. Telegrams: "Genefax, Middlesbrough." (Mr. J. A. Williams).

CARDIFF OFFICE: 17, Windsor Place. Telephone: 5796. Telegrams: "Genefax, Cardiff." (Mr. F. E. Rutter).



Raw Material Markets

With the Christmas holidays at hand, consumers of iron and steel have been less regular in their inquiries. Apart from holiday operations, this is invariably a quiet period of the year, as the annual stocktaking operations commence at the year-end. The markets retain their strength, and a resumption of activities will not be long delayed.

Pig-Iron

MIDDLESBROUGH.—Quite a good tonnage of foundry iron has changed hands on paper for delivery over the early months of next year. Supplies are likely to be fairly satisfactory, and consumers are therefore not too anxious to book far ahead. The fact that prices are fixed over the first half of the year is also a factor. A furnace now engaged on the production of basic iron is expected shortly to be transferred to foundry iron. If this change-over materialises, delivery arrears will be considerably lessened. No. 3 Cleveland G.M.B. is quoted at 109s. per ton for delivery in Middlesbrough and Falkirk over the first six months of next year, with Tyneside deliveries at 111s. and Glasgow 112s., less 5s. rebate. The hematite section of the market remains very active, and orders are heavy. Output is disposed of without delay, and production might easily be increased, despite the fact that it is now higher than it has been for a very long time. For delivery on the North-East Coast after December 31, East Coast mixed numbers are quoted at 132s. 6d., 138s. in Sheffield and 143s. 6d. in Birmingham, less 5s. per ton rebate.

LANCASHIRE.—Owing chiefly to the proximity of the year-end, with all that it entails, the pig-iron market has taken on a slightly quieter aspect. Also, several consuming plants are less active than they have been. Generally, however, good contract demands are being made. For delivery in the Lancashire price zone, Staffordshire and Derbyshire No. 3 grades are quoted on the basis of 114s. per ton, with Northamptonshire at 112s. 6d. The outlook among consumers for next year is satisfactory on the whole. The demand for hematite iron is well maintained.

MIDLANDS.—The demand appears to have been rather less insistent of late; this offers a welcome respite to some makers, as they still have leeway to make up before contract arrears are deleted from their order-books. In most cases, however, producers have iron to sell and are helping to relieve the tightness of the Cleveland and other markets. The motor-car industry, makers of light castings, and jobbing founders remain quiet, but order-books among foundry iron producers are well filled for the first half of next year. For delivery to Birmingham and Black Country stations, Northamptonshire No. 3 is quoted at £5 8s. 6d. and Derbyshire No. 3 at £5 11s., less 5s. per ton rebate. The price of low-phosphorus iron varies between £6 7s. 6d. and £7 10s., supplies being drawn from different parts of the country. Business in this grade is substantial. Refined iron is quoted at £8 5s. minimum. Consumers of hematite are negotiating for their requirements over varying periods of next year, although many users prefer not to book beyond the first half. For delivery after December 31, East Coast No. 3 is quoted at £7 3s. 6d., with West Coast mixed numbers at £7 4s. 6d. These prices are 10s. more than the quotations ruling at the present time, and are subject to 5s. rebate and 1s. 6d. per ton extra if delivered into works.

SCOTLAND.—Many consumers have already booked their requirements for the first six months of 1938. Business during the past week has been quieter. Scottish No. 3 foundry iron is quoted at 118s. f.o.t. furnaces, with No. 1 at 120s. 6d. No. 3 Cleveland is 109s. at Falkirk and 112s. at Glasgow, less 5s. rebate. In most cases, steelworks are satisfactorily situated as regards their pig-iron supplies. For delivery to local steelworks, hematite mixed numbers are quoted at 123s., Scottish basic at 107s. 6d. and English and Indian basic at 100s., less 5s. rebate.

Coke

Durham prices of foundry coke are already fixed, but Welsh quotations are not controlled. It is understood, however, that this position will shortly be changed, and that Welsh makers will establish some form of control. For delivery to Birmingham and district, best Durham foundry coke is quoted at a minimum of 55s. 9d., while Welsh coke varies, according to quality, from 55s. to 65s. per ton.

Steel

The quieter tone which has prevailed in the steel market recently is certain to be only of a temporary nature. After the holidays and the stocktaking operations have been passed, business will again be brisk. Contract deliveries continue to be made at a good rate, and there is no slackening at the steelworks. Semi-finished descriptions, particularly, are well taken up, but there is a lesser demand for some finished products. Demand from overseas consumers is still on the quiet side.

Scrap

Business was quite brisk right up to the holidays, but there have been some indications of a decline in demand recently. The stabilisation of prices for the first half of the year has enabled producers to make forward sales on a firm basis. There is certain to be a considerable amount of activity in this respect after the end of the year. There are reports, particularly from the northern districts, of deliveries having been delayed by the severe weather.

Metals

Apart from the usual seasonal quietness in the non-ferrous metal markets, there is a dullness which can only be attributed to other causes. Predominant, of course, is the unsettled international situation.

Copper.—Consumers appear to have little confidence in this market, which remains quiet. New business is of very meagre proportions. The American Smelting & Refining Company has now further reduced its price, by ⅛ cent to 10⅛ cents per lb. Japan is an active buyer at the present time, and heavy tonnages are destined to go to that country in the near future. The reasons for the fact that Japan desires prompt deliveries are, of course, quite plain. An increase of 30,680 tons in world copper stocks was brought about in the month of November. The apparent world consumption amounted to 155,000 tons. The world output by mines and smelters totalled 179,000 tons, while the world production of refined copper was 185,000 tons.

Metal Exchange quotations were as follow :—

Cash.—Thursday, £40 1s. 3d. to £40 3s. 9d.; Friday, £39 17s. 6d. to £39 18s. 9d.; Monday, £40 1s. 3d. to £40 2s. 6d.; Tuesday, £40 10s. to £40 11s. 3d.

Three Months.—Thursday, £40 6s. 3d. to £40 8s. 9d.; Friday, £40 2s. 6d. to £40 3s. 9d.; Monday, £40 5s. to £40 6s. 3d.; Tuesday, £40 15s. to £40 16s. 3d.

Tin.—This market still moves in an undetermined manner. Business is very quiet at the present time. The tinplate industry, both in this country and in the United States, is passing through a slack period. Operations at the mills in this country are around 68 per cent. of capacity, deliveries being slightly below the production, while American mills are working at under 60 per cent. of capacity. Reaction abroad to the decision of the International Tin Committee to reduce the quotas by 40 per cent. has been variable. Malayan opinion, as might be anticipated, is pretty well unanimous in condemning the decision. A redistribution of the total standard tonnages on the basis of proved productive capacity would be welcomed in Singapore. Dutch authorities, however, are more enthusiastic.

According to the Metallgesellschaft, the world's mine output of tin in October was 16,605 metric tons, making a total of 167,463 tons for the ten months of the year, as compared with 147,577 tons in the corresponding period of 1936.

Official quotations were as follow :—

Cash.—Thursday, £191 15s. to £192; Friday, £190 10s. to £190 15s.; Monday, £186 5s. to £186 7s. 6d.; Tuesday, £188 10s. to £188 15s.

Three Months.—Thursday, £191 to £191 5s.; Friday, £189 15s. to £190; Monday, £185 10s. to £186; Tuesday, £187 15s. to £188 5s.

Spelter.—This market continues to be disappointing, and there is no likelihood of any early improvement. Moderate activity continues among the galvanisers in this country, but the industry in the United States is employed at only around 36 per cent. of capacity.

Daily market prices :—

Ordinary.—Thursday, £15 2s. 6d.; Friday, £15; Monday, £15 1s. 3d.; Tuesday, £15 8s. 9d.

Lead.—Speaking at Edinburgh, Sir Harold Bellman, President of the International Congress of Building Societies, said that, so far as the country's economic fortunes were concerned, the housing boom had clearly been a factor of the first importance. To-day, however, there were unmistakable signs of a process of adjustment from boom to conditions which must be allowed to develop before one could define them. The plan figures relating to houses for the first ten months of this year were considerably below those for the corresponding period of the previous year, and there was other evidence of a transition to less active conditions. It would seem, therefore, that a reduced consumption of lead from this source must be envisaged.

The United States price has been lowered by ¼ cent to 4.75 cents per lb.

The Metallgesellschaft reports that the world's smelter output of lead in October was at a daily rate of 4,547 metric tons, against 4,542 tons in the previous month.

Day-to-day quotations :—

Soft Foreign (Prompt).—Thursday, £15 16s. 3d.; Friday, £15 15s.; Monday, £15 10s.; Tuesday, £15 15s.

Scrap.—There is the usual end-of-the-year atmosphere in this market, and business remains quiet.

Approximate selling prices for old metal :—New aluminium cuttings, £82; rolled, £67; cast, £40; foil, £94 to £98. Copper, £37 to £40; braziery, £36. Brass (clean), £24 to £26. Zinc, £9. Lead, £15. Gunmetal, £39 to £40.

Book Review

Der Bau und der Betrieb der Kupolofen. II.—Der Betrieb von Kupolofen. (The Construction and Operation of the Cupola; Vol II: The Operation of the Cupola). By L. Schmid. Published by Verlag von Wilhelm Knapp in Halle (Saale), Germany. Price: Paper backs, 8.62; bound, 9.52 renten marks.

This volume on cupola operation is one of a series on foundry practice, twenty-three of which have been issued, and is the second part of a volume devoted to the foundry cupola, of which the first, by the same author, dealt with construction. The four parts of the book deal respectively with the raw materials used in the cupola; the chemical and physical changes taking place in the stack; charges, compositions and charge calculations; and control of cupola operation. The literature references are almost wholly German, and practice elsewhere is covered only in so far as it has been described in these references. Subject to this, the book covers the ground extremely well and in a practical way. There are 235 pages and nearly 40 illustrations.

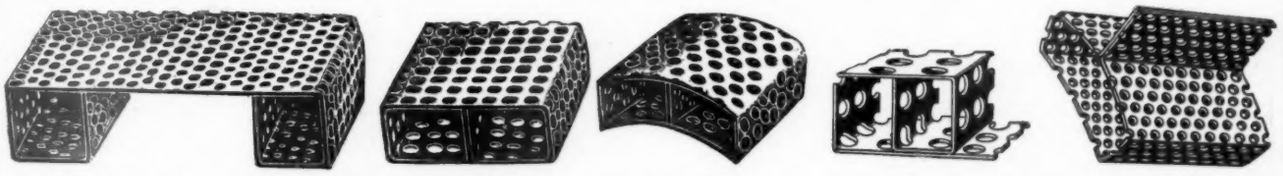
Enamel Formulæ for Sheet Steel

The following formula for a ground coat for vitreous enamelling sheet steel is given by E. L. STINE in "Metal Industry" (New York):—Borax, 30 lbs.; feldspar, 28 lbs.; quartz, 20 lbs.; soda ash, 11 lbs.; fluorspar, 6 lbs.; saltpetre, 4½ lbs.; ox. nickel, ½ lb.; ox. cobalt, 1 lb.; and ox. manganese, 1 lb. Grind in the mill to each 100 lbs., 6 per cent. enamel clay and 1½ per cent. carb. magnesia, with about 40 per cent. of cold water in the mill. As a typical white cover coat, the same writer gives the following formula:—Borax, 20 lbs.; feldspar, 43 lbs.; quartz, 12 lbs.; cryolite, 13 lbs.; fluorspar, 5 lbs.; soda ash, 10 lbs. and saltpetre, 2 lbs. Grind in the mill to each 100 lbs., 5 per cent. enamel clay and 6 per cent. oxide tin, with about 35 per cent. of cold water in the mill.

CHAPLETS & STUDS

FOR EVERY BRANCH OF FOUNDRY INDUSTRIES

PERFORATED CHAPLETS. ALL SHAPES—SIZES—AND THICKNESSES



PRECISION HYDRATITE STUDS & CHAPLETS FOR ALL CYLINDER CASTINGS

SEND US YOUR ENQUIRIES.

WE CAN QUOTE YOU RIGHT.

LARGE QUANTITIES OF STANDARD SIZES STOCKED.

ALSO MAKERS OF

DOOR CATCHES, HINGE TUBES & DOVE TAILS FOR THE GENERAL STOVE & RANGE TRADES.

SKIMMING GATES.

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CORE WIRES, PLAIN & TWISTED,

& ETC.

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CLIMAX WORKS, COLESHILL STREET, BIRMINGHAM 4.

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'Grams: Precico, Phone, Birmingham.

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USE PRECISION STUDS AND CHAPLETS FOR BETTER RESULTS.

WARNER Special PIG IRONS

- Warner C.B.R. and Low Carbon Cylinder (FOR CYLINDERS, ROLLS, ENGINEERING CASTINGS, ETC.)
- Low Carbon Malleable (FOR MALLEABLE CASTINGS OF ALL DESCRIPTIONS)

Supplied to any specification between limits of 2·00 and 3·50% Carbon and ·50% and 3·50% Silicon

ACTUAL ANALYSIS CERTIFICATES ARE AVAILABLE WITH EACH DELIVERY

● **Typical Cylinder Pig Iron Specification**

TOTAL CARBON	2·70%
SILICON	1·80%
MANGANESE	·90%
SULPHUR	·06%
PHOSPHORUS	·40%

● **Typical Malleable Pig Iron Specification**

TOTAL CARBON	2·60%
SILICON	·75%
MANGANESE	·50%
SULPHUR	·05%
PHOSPHORUS	·06%

WARNER & CO. LTD

CARGO FLEET · MIDDLESBROUGH

RAW MATERIALS—PRICE LIST

(Tuesday, December 21, 1937)

COPPER

	£ s. d.
Standard cash	40 10 0
Three months	40 15 0
Electrolytic	44 0 0
Tough	43 5 0
Best selected	43 15 0
Sheets	74 0 0
India	54 7 6
Wire bars	45 0 0
Ingot bars	44 15 0
H.C. Wire rods	48 10 0
Off. av. cash, Nov.	39 7 $4\frac{7}{11}$
Do., 3 mths., Nov.	39 13 $0\frac{3}{22}$
Do., Sttlmnt., Nov.	39 7 $7\frac{4}{11}$
Do., Electro, Nov.	44 18 $7\frac{7}{11}$
Do., B.S., Nov.	44 19 $8\frac{3}{4}$
Do., Wire bars, Nov.	45 16 $9\frac{9}{11}$
Solid drawn tubes	122½d.
Brazed tubes	122½d.
Wire	81½d.

BRASS

Solid drawn tubes	111½d.
Brazed tubes	131½d.
Rods, drawn	91½d.
Rods, extd. or rlld.	61½d.
Sheets to 10 w.g.	81½d.
Wire	83½d.
Rolled metal	81½d.
Yellow metal rods	63½d.

TIN

	£ s. d.
Standard cash	188 10 0
Three months	187 15 0
English	188 10 0
Bars	190 10 0
Straits	192 10 0
Eastern	192 17 6
Banca (nom.)	—
Off. av. cash, Nov.	190 13 $7\frac{7}{11}$
Do., 3 mths., Nov.	190 5 $1\frac{4}{11}$
Do., Sttlmt., Nov.	190 14 $3\frac{9}{11}$

SPELTER

	£ s. d.
Ordinary	15 8 9
Remelted	12 5 0
Hard	12 0 0
Electro, 99.9	19 3 9
English	16 10 0
India	14 15 0
Zinc dust	23 15 0
Zinc ashes	6 0 0
Off. aver., Nov.	15 17 $9\frac{9}{22}$
Aver., spot, Nov.	15 16 $1\frac{13}{44}$

LEAD

	£ s. d.
Soft foreign, ppt.	15 15 0
Empire (nom.)	16 6 3
English	17 15 0
Off. aver., Nov.	16 14 $2\frac{5}{11}$
Aver. spot, Nov.	16 14 $1\frac{19}{44}$

ALUMINIUM

Ingots	£100 to £105
Wire	1/3 to 1/4 lb.
Sheet and foil	1/2 to 1/4 lb.

ZINC SHEETS, &c.

	£ s. d. £ s. d.
Zinc sheets, English	29 0 0 to 29 10 0
Do., V.M. ex-whse.	29 0 0 to 29 10 0
Rods	23 0 0

ANTIMONY

	£ s. d. £ s. d.
English	81 0 0 to 82 0 0
Chinese, ex-whse. (nom.)	64 0 0
Crude, c.i.f.	37 0 0

QUICKSILVER

Quicksilver	13 0 3

FERRO-ALLOYS AND STEEL-MAKING METALS

Ferro-silicon—	
25%	14 10 0
45/50%	12 0 0
75%	17 0 0
Ferro-vanadium	
35/50%	12/8 lb. Va.
Ferro-molybdenum—	
70/75% carbon-free	4/9 lb. Mo.
Ferro-titanium—	
20/25% carbon-free	9d. lb.
Ferro-phosphorus, 20/25%	£21 to £22
Ferro-tungsten—	
80/85%	9/3 lb.
Tungsten metal powder—	
98/99%	9/6 lb.
Ferro-chrome—	
2/4% car.	34 15 0
4/6% car.	24 5 0
6/8% car.	24 0 0
8/10% car.	24 0 0
Ferro-chrome—	
Max. 2% car.	36 0 0
Max. 1% car.	38 5 0
Max. 0.5% car.	41 0 0
70% carbon-free	10d. lb.
Nickel—99.5/100%	£180 to £185
"F" nickel shot	£165 0 0
Ferro-cobalt, 98/99%	8/6 to 8/9 lb.
Metallic chromium—	
96/98%	2/5 lb.
Ferro-manganese—	
76/80% loose	£18 15 0 to 19 5 0
76/80% packed	£19 15 0 to 20 5 0
76/80% export	£22 0 0
Metallic manganese—	
94/96% carbon-free	1/3 lb.

Per ton unless otherwise stated, basis 2-ton lots.

HIGH-SPEED TOOL STEEL

Finished bars, 14% tungsten	3s. 10d.
Finished bars, 18% tungsten	5s. 0d.

Per lb. d/d buyers' works.

Extras—

Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under ½ in. to ¼ in.	3d. lb.
Do., under ¼ in. to 7/32 in.	1/- lb.
Flats, ½ in. × ¼ in. to under 1 in. × ⅛ in.	3d. lb.
Do., under ¼ in. × ¼ in.	1/- lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra.

SCRAP

	£ s. d.	£ s. d.
South Wales (West)—		
Heavy steel, best	3 8 9	to 3 11 3
Mixed iron and steel	3 6 9	to 3 9 3
Heavy cast iron	3 8 9	to 3 11 3
Good machinery		3 17 6
Cleveland—		
Heavy steel, best	3 7 0	to 3 9 6
Steel turnings	2 13 0	to 2 15 6
Heavy cast iron		4 5 0
Heavy machinery		4 10 0
Midlands—		
Short heavy steel		4 0 0
Light cast-iron scrap	3 0 0	to 3 2 6
Heavy wrought iron	4 0 0	to 4 5 0
Steel turnings	2 5 6	to 2 8 0
Scotland—		
Heavy steel, best	3 5 0	to 3 7 6
Ordinary cast iron	4 5 0	to 4 7 6
Cast-iron borings	2 0 0	to 2 2 6
Wrot-iron piling		4 15 0
Heavy machinery	4 10 0	to 4 12 6

London—Merchants' buying prices, delivered yard.

Copper (clean)	32 0 0
Brass	23 10 0
Lead (less usual draft)	14 0 0
Tea lead	11 10 0
Zinc	9 0 0
New aluminium cuttings	71 0 0
Braziery copper	29 0 0
Gunmetal	32 0 0
Hollow pewter	135 0 0
Shaped black pewter	97 0 0

PIG-IRON*

N.E. Coast (d/d Tees-side area)—	
Foundry No. 1	108/6
,, No. 3	100/-
,, No. 4	105/-
Forge No. 4	105/-
Hematite No. 1	123/-
Hematite M/Nos.	122/6
N.W. Coast—	
Hem. M/Nos. d/d Glas.	123/-
,, d/d Birm.	134/6
Malleable iron d/d Birm.	160/-
Midlands (d/d Birmingham dist.)—	
Staffs No. 4 forge	108/-
,, No. 3 fdry.	111/-
Northants forge	105/6
,, fdry. No. 3	108/6
,, fdry. No. 1	111/6
Derbyshire forge	108/-
,, fdry. No. 3	111/-
,, fdry. No. 1	114/-
Scotland—	
Foundry, No. 1, f.o.t.	120/6
,, No. 3, f.o.t.	118/-
Cleveland No. 3, Glasgow	112/-
,, ,, Falkirk	109/-
Scottish hem. M/Nos. d/d	123/-
Sheffield (d/d district)—	
Derby forge	105/6
,, fdry. No. 3	108/6
Lincs forge	105/6
,, fdry. No. 3	108/6
W.C. hematite	128/6
Lancashire (d/d eq. Man.)—	
Derby fdry, No. 3	114/-
Staffs fdry. No. 3	114/-
Northants fdry. No. 3	112/6
Cleveland fdry. No. 3	114/-
Glengarnock, No. 3	141/-
Clyde, No. 3	141/-
Monkland, No. 3	141/-
Summerlee, No. 3	141/-
Eglinton, No. 3	141/-
Gartsherrie, No. 3	141/-
Shotts, No. 3	141/-

(* Prices of hematite and basic pig-iron, and of foundry and forge iron with a phosphoric content of not less than 0.75 per cent., are subject to a rebate of 5s. per ton under certain conditions.)

FINISHED IRON AND STEEL

Usual district deliveries.

[A rebate of 15/- per ton for steel sections, plates and joists is obtainable in the home trade under certain conditions.]

Iron—	£ s. d.	£ s. d.
Bars (cr.)	13 5 0	to 13 15 0
Nut and bolt iron	11 12 6	to 12 2 6
Hoops		14 2 6
Marked bars (Staffs) f.o.t.		15 15 0
Gas strip		14 2 6
Bolts and nuts, ½ in. × 4 in.		17 10 0 and up
Steel—		
Plates, ship, etc.	11 8 0	to 11 10 6
Boiler plts.	11 18 0	to 12 0 6
Chequer plts.		13 0 6
Angles		11 0 6
Tees		12 0 6
Joists		11 0 6
Rounds and squares, 3 in. to 5½ in.		12 0 6
Rounds under 3 in. to ⅜ in. (Untested)		11 9 0
Flats—8 in. wide and over		11 5 6
,, under 8 in. and over 5 in.		11 10 6
Rails, heavy		10 2 6
Fishplates		14 2 6
Hoops (Staffs)		12 4 0
Black sheets, 24g. (4-t. lots)		15 15 0
Galv. cor. shts. (,,)		19 10 0
Galv. flat shts. (,,)		20 0 0
Galv. fencing wire, 8g. plain		20 5 0
Billets, soft, 100-ton lots		7 17 6
Sheet bars		7 15 0
Tin bars		7 15 0

PHOSPHOR BRONZE

	Per lb. basis
Strip	11d.
Sheet to 10 w.g.	11½d.
Wire	12⅞d.
Rods	13½d.
Tubes	18⅜d.
Castings	15½d.

Delivery 3 cwt. free.
10% phos. cop. £33 above B.S.
15% phos. cop. £38 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. CLIFFORD & SON, LIMITED.

NICKEL SILVER, &c.

	Per lb.
Ingots for raising	8d. to 1/2
Rolled—	
To 9 in. wide	1/2 to 1/8
To 12 in. wide	1/2½ to 1/8½
To 15 in. wide	1/2⅔ to 1/8½
To 18 in. wide	1/3 to 1/9
To 21 in. wide	1/3½ to 1/9½
To 25 in. wide	1/4 to 1/10
Ingots for spoons and forks	8d. to 1/4½
Ingots rolled to spoon size	11d. to 1/7½
Wire round—	
to 10g.	1/5½ to 2/0½

with extras according to gauge.
Special 5ths quality turning rods in straight lengths, 1/4½ upwards.

AMERICAN IRON AND STEEL

At Pittsburgh unless otherwise stated.

	Dols.
No. 2 foundry, Phila.	25.76
No. 2 foundry, Valley	24.00
No. 2 foundry, Birm.	20.38
Basic, Valley	23.50
Malleable, Valley	24.00
Grey forge, Valley	23.50
Ferro-mang. 80%, seaboard	102.50
O.-h. rails, h'y, at mill	42.50
Billets	37.00
Sheet bars	37.00
Wire rods	47.00
	Cents.
Iron bars, Chicago	2.40
Steel bars	2.45
Tank plates	2.25
Beams, etc.	2.25
Skelp, grooved steel	2.10
Steel hoops	2.40
Sheets, black, No. 24	3.15
Sheets, galv., No. 24	3.80
Wire nails	2.75
Plain wire	2.90
Barbed wire, galv.	3.40
Tinplates, 100-lb. box	$5.35

COKE (at ovens)

Welsh foundry	42/6
,, furnace	37/6
Durham foundry	38/6
,, furnace	37/6
Scottish foundry	42/6
,, furnace	40/-

TINPLATES

f.o.b. Bristol Channel ports.

I.C. cokes 20×14 per box	22/6
,, 28×20 ,,	45/-
,, 20×10 ,,	35/-
,, 18¾×14 ,,	25/-
C.W. 20×14 ,,	19/6
,, 28×20 ,,	39/-
,, 20×10 ,,	30/6
,, 18¾×14 ,,	21/6

SWEDISH CHARCOAL IRON & STEEL

	£ s. d. £ s. d.
Pig-iron	£12 0 0 to £13 0 0
Bars-hammered, basis	£20 0 0 to £22 0 0
Bars and nail-rods, rolled, basis	£19 0 0 to £20 0 0
Blooms	£18 0 0 to £19 0 0
Keg steel	£30 0 0 to £35 0 0
Faggot steel	£20 0 0 to £25 0 0
Bars and rods dead soft st'l	£19 0 0 to £20 0 0

All per English ton, f.o.b. Gothenburg.
[Subject to an exchange basis of Kr. 19.39 to £1.]

DAILY FLUCTUATIONS

Standard Copper (cash)

			£	s.	d.		
Dec.	16	..	40	1	3	inc.	11/3
,,	17	..	39	17	6	dec.	3/9
,,	20	..	40	1	3	inc.	3/9
,,	21	..	40	10	0	,,	8/9

Standard Tin (cash)

			£	s.	d.		
Dec.	16	..	191	15	0	inc.	20/-
,,	17	..	190	10	0	dec.	25/-
,,	20	..	186	5	0	,,	85/-
,,	21	..	188	10	0	inc.	45/-

Spelter (ordinary)

			£	s.	d.		
Dec.	16	..	15	2	6	inc.	5/-
,,	17	..	15	0	0	dec.	2/6
,,	20	..	15	1	3	inc.	1/3
,,	21	..	15	8	9	,,	7/6

Lead (soft foreign, prompt)

			£	s.	d.		
Dec.	16	..	15	16	3	inc.	2/6
,,	17	..	15	15	0	dec.	1/3
,,	20	..	15	10	0	,,	5/-
,,	21	..	15	15	0	inc.	5/-

Electrolytic Copper

			£	s.	d.		
Dec.	16	..	44	0	0	inc.	15/-
,,	17	..	44	0	0	No change	
,,	20	..	44	0	0	,,	,,
,,	21	..	44	0	0	,,	,,

Tin (English ingots)

			£	s.	d.		
Dec.	16	..	191	15	0	inc.	20/-
,,	17	..	190	10	0	dec.	25/-
,,	20	..	186	5	0	,,	85/-
,,	21	..	188	10	0	inc.	45/-

Spelter (Electro, 99.9 per cent.)

			£	s.	d.		
Dec.	16	..	18	18	9	inc.	6/3
,,	17	..	18	16	3	dec.	2/6
,,	20	..	18	16	3	No change	
,,	21	..	19	3	9	inc.	7/6

Lead (English)

			£	s.	d.		
Dec.	16	..	18	0	0	inc.	5/-
,,	17	..	18	0	0	No change	
,,	20	..	17	10	0	dec.	10/-
,,	21	..	17	15	0	inc.	5/-

AVERAGE MONTHLY PRICES OF UNMARKED BARS (SOUTH STAFFS)

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly average
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1902	7 0 0	6 10 0	6 15 0	6 15 0	6 15 0	6 10 0	6 10 0	6 15 0	6 15 0	6 15 0	6 10 0	6 10 0	6 13 4
1903	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 7 0	6 5 0	6 9 4½
1904	6 5 0	6 5 0	6 5 0	6 5 0	6 10 0	6 5 0	6 0 0	6 0 0	6 0 0	6 0 0	6 0 0	6 0 0	6 2 11½
1905	6 5 0	6 5 0	6 0 0	5 17 6	5 15 0	5 15 0	5 15 0	5 15 0	6 0 0	6 5 0	6 15 0	6 15 0	6 1 10
1906	7 0 0	7 5 0	7 5 0	7 5 0	6 17 6	6 15 0	6 12 6	6 10 0	6 10 0	6 12 6	6 16 3	7 3 9	6 17 8
1907	7 3 9	7 5 0	7 5 0	7 5 0	7 5 0	7 7 6	7 5 0	7 7 6	7 7 6	7 7 6	7 7 6	7 5 0	7 5 11
1908	7 2 6	7 0 0	7 0 0	7 0 0	6 15 0	6 7 6	6 5 0	6 2 6	6 2 6	6 2 6	6 2 6	6 0 0	6 10 0½
1909	6 0 0	6 0 0	6 0 0	5 17 6	6 0 0	6 0 0	6 0 0	5 17 6	6 0 0	6 2 6	6 2 6	5 17 6	5 19 9
1910	6 2 6	6 3 4½	6 7 6	6 7 6	6 7 6	6 7 6	6 6 6	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 5 7
1911	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 10 0	6 12 6	6 16 6	6 7 0
1912	6 18 9	7 1 10	7 2 6	7 8 9	7 18 0	8 0 7	8 2 6	8 3 6	8 5 0	8 6 3	8 7 6	8 8 9	7 17 0
1913	8 11 6	8 10 7½	8 10 0	8 8 1½	8 2 0	8 0 0	7 17 6	7 11 6	7 8 9	7 5 6	6 18 1½	6 17 6	7 16 9
1914	6 17 6	6 15 7½	6 12 6	6 10 0	6 10 0	6 10 0	6 10 0	7 11 10½	8 0 0	7 12 6	7 5 7½	7 6 3	7 1 0
1915	7 11 6	8 5 11	8 8 9	9 6 0	10 3 2	10 19 2	11 12 6	11 13 1½	11 13 9	11 14 3	12 1 10½	13 0 9	10 6 0½
1916	13 7 6	13 10 8	13 12 9½	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 8 9
1917	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0½
1918	13 15 0	13 17 3	13 17 6	13 17 6	13 17 6	13 17 6	13 17 6	14 15 0	14 15 0	14 15 0	14 15 0	14 15 0	14 4 5
1919	15 10 0	16 5 0	17 15 0	17 15 0	20 15 0	21 0 0	21 0 0	22 0 0	22 0 0	22 0 0	22 7 6	22 12 6	20 1 8
1920	24 7 6	24 10 0	25 10 0	27 10 0	29 5 0	31 0 0	31 10 0	31 10 0	31 10 0	31 10 0	31 10 0	29 7 6	29 1 8
1921	26 17 3	25 0 0	23 0 0	21 0 0	19 0 0	18 5 0	16 0 0	16 0 0	15 14 0	14 0 0	13 6 8	13 0 0	19 4 5½
1922	13 0 0	12 3 9	11 14 0	11 11 10½	11 5 0	11 3 6	11 2 6	11 5 0	10 17 2½	10 16 3	10 13 0	10 12 6	11 7 0½
1923	10 16 10½	11 3 1½	12 2 6	12 8 9	12 11 6	12 1 3	11 15 11½	11 15 0	11 15 0	11 15 0	12 13 6	12 8 3	11 18 10½
1924	12 9 6	12 10 0	12 10 0	12 15 7½	12 17 6	12 17 6	12 17 6	12 17 6	12 17 6	12 14 0	12 12 6	12 12 6	12 14 9½
1925	12 12 6	12 12 6	12 12 6	12 12 6	12 12 6	12 7 6	12 7 6	12 7 6	12 4 6	11 18 6	11 13 9	11 13 0	12 6 2
1926	11 7 9½	11 5 0	11 5 0	11 5 0	11 3 9	11 3 9	11 5 0	12 0 0	13 0 0	*	15 7 6	12 10 0	12 0 2
1927	12 6 3	12 2 6	11 14 0	11 0 0	10 18 9	10 13 6	10 12 6	10 5 0	9 16 0	9 15 0	9 13 9	9 12 9	10 14 2
1928	9 12 6	9 12 6	9 11 0	9 10 0	9 8 4	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 3 6	8 1 3	9 7 0
1929	9 0 0	9 2 6	9 5 7½	9 9 4½	9 10 0	9 17 6	10 2 6	10 2 6	10 2 6	10 0 6	10 3 0	10 5 7	9 15 2½
1930	10 7 6	10 7 6	10 7 6	10 6 10½	10 6 3	10 5 0	10 2 6	10 2 6	10 2 6	10 2 6	10 2 6	10 2 6	10 4 7½
1931	10 2 6	10 0 0	10 0 0	10 0 0	9 18 1½	9 17 6	9 17 6	9 17 6	9 17 6	9 17 6	9 17 6	9 16 10½	9 18 0½
1932	9 15 0	9 15 0	9 15 0	9 15 0	9 13 9	9 11 3	9 10 0	9 10 0	9 10 0	9 6 3	9 5 0	9 5 0	9 10 11½
1933	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0
1934	9 5 0	9 8 1½	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 11 6
1935	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6	9 12 6
1936	9 12 6	9 15 0	10 2 6	10 2 6	10 2 6	10 6 3	10 10 0	10 10 0	10 10 0	10 10 0	10 10 0	10 10 0	10 4 5½
1937	10 10 0	10 10 0	11 17 6	11 17 6	11 17 6	11 17 6	12 4 6	13 5 0	13 5 0	13 5 0	13 5 0	—	—

* No quotation available owing to strike.

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